ARROYO SECO

SCIENTIFIC AMERICAN SUPPLEMENT

Copyright 1917 by Munn & Co., Inc.

VOLUME LXXXIV] NUMBER 2181 ★ NEW YORK, OCTOBER 20, 1917 ★ [10 CENTS A COPY $5.00 A YEAR

The Gillam Service

A "Zep-Getter" on an American Battleship

SHELLING THE ENEMIES IN THE AIR [See page 254]

Homeomerism*

The Systemization of Physico-Chemical Analogies

[Editorial Note.—In this article Prof. G. Urbain of the Faculty of Sciences of the University of Paris presents a valuable outline of the comparatively new department of scientific research dealing with chemico-physical analogies to which he has given the new but self-explanatory title of Homeomerism. This memoir is of great interest to the general reader as well as to the professional scientific investigator. We omit portions of sections 3 and 4, however, containing mathematical formulæ of importance to the latter, but not essential to the former in comprehension of the general theme and its wide application.]

I.—CERTAIN substances of the same chemical composition possess different properties. Facts of this order justly impressed the imagination of the chemist who first discovered them. At an epoch when the central problem consisted of the generalization of the laws which govern the quantitative composition of pure substances the opinion was formed that the properties of bodies depend exclusively upon their chemical composition, and it seemed extraordinary that substances possessing distinct properties might still have the same composition. Here was an entirely new idea to be fixed in the minds of the chemist of the time and of the time to come; Berzelius, therefore, with the conviction that no new idea could become current without a new name, proposed for this phenomenon the word "isomerism."

Is it necessary to expatiate upon the importance attributed to this idea of isomerism? We believe not; every chemist knows what to think upon this point. Theoretically, isomerism has always been considered as of capital importance; every one is convinced of the necessity of bearing in mind this fact that bodies having the same chemical composition may have distinct properties.

But from the point of view of research isomerism is no longer a central problem; the composition of bodies has ceased to fix exclusively the attention of investigators. At present the interest attaching to the properties of substances bears rather upon what relates to their composition, for no one longer doubts the validity of the fundamental stoechiometric laws; and in place of seeking to verify these laws, investigators rely upon them as the soundest foundations of modern science.

Today the study of the properties of bodies and of the relations which exist between these properties is well developed. It is the sole object of physical chemistry. For us these properties possess the same interest which the chemists of the first half of the last century found in the composition of bodies. Our researches correspond to theirs, so to speak, symmetrically, and that which they found remarkable in relation to the composition of bodies becomes so to us in relation to their properties. This is why we may consider it as worthy of remark that certain bodies may possess common properties though differing in composition.

Facts of this kind are extremely frequent in chemistry. Isomorphism, whose importance is now scarcely contested enters as a particular feature into the framework of facts which the preceding remark embraces, and for which I propose the name of *Homeomerism*.

Thus, homeomerism is to the properties of bodies what isomerism is to their composition.

Two bodies are homeomeric when they have common properties though their chemical composition may be different.

But while isomerism is always rigorously precise, homeomerism is never more than approximately so. Two bodies which differ in chemical composition never have absolutely identical properties; but their properties may approximate each other more or less nearly.

In certain cases, as in that of the Rare Earths, certain properties may be practically identical; in other cases these properties may be merely very similar. This is the case in the Triad, Chlorine—Bromine—Iodine.

Homeomerism is always only partial and seems to admit of all sorts of degrees. To undertake its study is to systematize the physico-chemical analogies. But analogy is the lever operative in all research. By endeavoring to systematize analogies we seek to put ideas in order, to simplify the efforts of the intelligence, and to make happy selections among the chaos of comparisons which present themselves more or less fortuitously to the mind of the investigator.

In what follows I shall attempt to show how such a question may be atacked in a really scientific manner, for if I do not pretend to solve so vast a problem at first approach I can at least present it.

II.—In the first place it is necessary to distinguish between the different properties of a body. Certain ones of them are strictly organoleptic, as color, odor, appearance. Such characteristics are of but secondary interest from the scientific point of view. They are, to be sure, useful to the analyst, but being rarely expressible in terms of number, they rarely permit the theorist to base relations of analogy upon them.

Under the name of "chemical properties" we consider the fashion in which a body undergoes transformation, either in the presence of other bodies, or else of itself under certain conditions. The determination of chemical properties is thus the essence of chemistry itself. Hence the word "property" is not very appropriate to its object; the precise term would be a literal translation of the English word "behavior," *i. e.*, its *manner of conducting itself*, in other words, its "conduct."

In the last resort it is precisely this "chemical conduct" which we wish to learn, this is our object, and it is the means of attaining this object which we must consider. We admit in principle that the "chemical conduct" of a body depends at once upon its composition and upon its properties. The properties which we thus consider could not signify "chemical conduct," for then the principle from which we start would be a mere tautology. What we must consider under the head of properties are magnitudes susceptible of being measured which lend themselves to quantitative experimentation. These properties, moreover, should be general, for without this quality they would not permit of the comparison of bodies with each other.

Hence it is to very general orders of facts that we must address ourselves to determine properties which are useful to the end we have in view. The phenomena of energy come under this head; for every body may be the seat of transformation—mechanical, thermic, electrical, etc. . . . What, from various points of view, differentiates bodies from each other, are the numerical values of the differential coefficients, such as coefficients of dilatation, of compressibility, specific heats and latent heats, etc., which all bodies necessarily present.

Thus the energetic coefficients relate to a very precise group of properties capable of serving for the comparison of bodies with each other. These properties are certainly not the only ones in this case, but they are, on the one hand, those which possess the greatest practical interest, and on the other hand they are those of which we can speak with most knowledge in the present state of science.

It may be remarked, that since chemical transformations come into play in energetic phenomena, it is not impossible to define chemical coefficients which bear a relation to what, properly speaking, we ought strictly to call "chemical properties." At any rate, for reversible phenomena, the knowledge of such differential chemical coefficients will explain to us "chemical conduct" under given conditions, and enable us to foresee it. These chemical coefficients would be necessarily expressed in function of variables chosen to represent the chemical state of the body. We know that such variables may be divided into two groups: factors of action and factors of quantity. These factors enter by couples into the expression of every special form of energy.

Thus a chemical energy may be represented by the product of a mass by a chemical potential, or, again, by the product of a concentration by a factor having the same role from the chemical point of view that entropy has from the thermic point of view.

The existence of relations between the energetic coefficients of the same body is imposed, on the one hand, by the very definitions of these coefficients, and on the other hand by the two fundamental principles of thermodynamics. The physical properties of a body or of an *ensemble* of bodies thus depend upon the chemical properties of that body or that *ensemble* of bodies.

The principle of dependence of the various physico-chemical properties, which serves as a directing idea, is justified, at least as far as the energetic properties are concerned, by the simple considerations preceding.

It is upon these grounds, now very solidly established, that it is fitting to rest the analogies of bodies to systematize them in chemistry.

III.—The physical properties of a body or of a system of bodies are interdependent. These dependencies derive, some from the definitions of the coefficients themselves, the others result from the principles of thermodynamics.

They can be easily demonstrated in the case of a thermo-elastic system, *i. e.*, a system enclosed within the body of a pump and undergoing exchanges from the exterior of thermic or mechanical nature only. From our point of view these relations assume so much importance that we shall here review them. . . .

(Here follows a series of mathematical equations concerning the relations between these thermo-elastic coefficients. As stated above these are omitted as not essential to the comprehension of the article by the general reader, though of value to experts in mathematical physico-chemistry.)

Thus these relations are, as we see, very numerous. They increase in the same degree as the number of variables, which is particularly the case with chemical systems.

It is incontestable, therefore, that all the energetic properties depend upon each other, and that in particular the "chemical conduct" of a body depends upon its thermic and mechanical properties. The latter may, therefore, serve as a basis for the systematization of chemical analogies.

IV.—We can deduce from the preceding observations a remarkable consequence capable of lending precision to the idea of homeomerism.

From the thermo-elastic point of view the knowledge of the properties of a body may be reduced to that of nine coefficients; but since necessary relations exist between these various coefficients, it is sufficient for us to know a smaller number in order to know them all.

In chemistry there is an advantage in referring the coefficients, not to the unit of mass, but to the molecular mass. In consequence if two bodies have at once the same molecular volume and four of the defined coefficients equal they will be strictly similar from a thermo-elastic point of view. Their thermo-elastic homeomerism will be complete. From every other point of view they will be more or less homeomers. From the chemical point of view in particular they will have in general very close analogies.

The demonstration which has been made in the simplest case of a system which is strictly thermo-elastic could likewise be made for a chemical system. But the demonstration would lead to very long calculations from which the present state of our knowledge would not permit us to derive any immediate practical advantage.

This is why I confine myself in this first attempt to the thermo-elastic homeomerism of bodies having the same molecular volume.

V.—Let us consider three bodies possessing a strong similarity: chlorine, bromine, iodine. In the gaseous state these bodies are certainly homeomers: they have the same molecular volume (law of Gay-Lussac); the same coefficients of compressibility (law of Mariotte); the same molecular specific heat as well at a constant volume as at a constant pressure (law of Neumann).

It is infinitely probable that these same characteristics of homeomerism are likewise found in these bodies in both the liquid and the solid states as well as in the systems of multiple phases which each is capable of forming. But this is a point which present data do not permit us to positively affirm. The systems which each of these bodies is able to form with hydrogen are doubtless also homeomers, since we find in hydrochloric, hydrobromic, and hydriodic acids the essential characteristics of homeomerism.

What has just been said concerning the halogens might be repeated for all the elements of any natural group.

Thus it seems clear that in chemistry all systemization rests upon the relations of homeomerism; but instead of having proceeded in the methodical fashion indicated in the preceding analysis, the history of investigation is that it has followed the empirical mode which is that of the earliest lispings of every science.

Revue Scientifique (Paris).

VI.—Isomorphism would appear to be a highly specialized case of homeomerism. It is obvious, in fact, that syncrystallization is possible only when bodies can mutually replace each other in the same crystalline network, which implies equality of the molecular volumes. The *network* can not resist the action of heat unless the bodies dilate in the same manner; nor mechanical action unless they suffer compression in the same manner, etc.; herein we have the relations of homeomerism precisely stated

M. Dohem,[1] basing his conclusions upon the theory of the thermo-dynamic potential, holds, by reason of his study of isomorphism, that the syncrystallization of two chemical species involves in the same conditions of temperature pressure:

The same molecular volume;

The same coefficient of dilatation under constant pressure;

The same coefficient of dilatation under constant volume;

The same coefficient of compressibility;

The same molecular specific heat under constant pressure;

The same specific heat under constant volume.

We have here more conditions required than are necessary in order for two bodies to have all the thermo-elastic coefficients equal to each other.

Two bodies which are syncrystallizable are homeomers by that very fact. However homeomerism does not necessarily imply either syncrystallization or even identity of crystalline form. The idea of homeomerism is more general than that of isomorphism. Two amorphous bodies, two liquids, two polyphasic systems may be homeomers without involving their isomorphism, but syncrystallization, thanks to the results of M. Dohem, dispenses with the measuring of the whole series of constants whose determination would be imposed by the thoery of homeomerism; and this is an observation of great practical value.

VII.—This is the place to say a few words regarding the law of Mitscherlish against which so much has been written in recent years. If isomorphism and syncrystallization in particular result from homeomeric relations, it is logical that the majority of cases of isomorphism should relate to bodies of the same constitution, especially in the case of elements which give rise, in their various compounds, to multiple cases of isomorphism. This indicates that the relations of homeomerism presented by bodies belonging to the same natural group are generally extended to the systems which these bodies may form with one or more bodies belonging to another group. (Sec. 5.)

We shall see, in fact, that the choice of atomic weights is based strictly upon the relations of homeomerism.

But compounds of very different constitution may be homeomers also, and isomorphs also; but this is a possibility which no longer results from the homeomerism of the constituents of these compounds, is so rare that it may be looked upon as fortuitous.

The statement of Mitscherlish is not a law, but a rule, permitting the choice of an atomic weight among several possible equivalents.

VIII.—We will close this preliminary study by showing that the atomic theory has no other experimental basis than the relations of homeomerism, and that it is to this that that doctrine owes its coherence and its success.

The present atomic theory rests upon two definitions: that of the molecule and that of the atom. The definition of the molecule results from Avogadro's hypothesis; the chemical atom is defined consequently as the smallest quantity of an element which can exist in a molecule.

It results from the first definition that the ratio of the density of two gases is equal to the ratio of their molecular weights. The molecular weight of a body is expressed by its gaseous density with reference to double that of hydrogen, which is chosen as a unit. Knowing the molecular weight of a body and the atomic weight of all its constituents, except one, we can deduce a *maximum* value of the atomic weights of this last constituent.

After having determined the density of the vapor of the largest possible number of derivatives of the same element, we select as the atomic weight of this element the smallest value among the maximum values obtained.

Following upon this brief and strictly didactic exposition, the analogies are presented as consequences of the *reality* (!) of the theory. If the atomic theory were contained in this bald exposition it would be reduced to a pure verbalism. Its content is far more vital; we find it in the history of this beautiful question. And history teaches us that the choice of atomic weights has always had analogy for a guide.

Hesitations have referred solely to the choice of these analogies. But it is evident that if the theory is coherent it is certain that these analogies have been well chosen. But it is manifest that these latter may be reduced, in the last analysis, to relations of homeomerism.

Why, in fact, is it that gases have been chosen to define the chemical molecule? Because gases obviously permit of the same characteristic equation, which signifies that all gases plainly have the same coefficient of dilatation (law of Gay-Lussac), and the same coefficient of compressibility (law of Mariotte).

These identities are relations of homeomerism.

Why has isomorphism been chosen as a criterion for the choice of an atomic weight among several possible equivalents? Because isomorphic bodies possess an *ensemble* of common properties; because they are strict homeomers from a thermo-elastic point of view, and at least partially so from a chemical point of view.

Finaly, why is an appeal so often made to the law of Dulong and Petit? Because this law expresses the fact that simple bodies in the solid state have obviously the same atomic heat, which again is a relation of homeomerism.

The coherence of the system of atomic weights, deduced from gaseous densities, from specific heats, from isomorphism, rests upon the fact that these criteria are related and exhibit more or less clearly thermic and elastic coefficients between which necessary relations exist. In this system it is these inevitable relations which constitute the coherence.

I hope I have thus demonstrated that the choice of atomic weights has until now had its origin hidden in what I have termed homeomerism, which must be considered as the surest guide in researches concerning physico-chemical analogies.

The Effect of X-rays Upon Diseases of Bacterial Origin*

By Christopher Kempster, M.R.C.S., L.R.C.P., Lond.,

Physician in charge of x-ray and electro-therapeutic departments of St. John's Hospital for diseases of the skin and City of London Military Hospital; assistant, x-ray and electro-therapeutic department, Cancer Hospital, London

DURING recent years there has been an increasing application of the X rays as a means of treatment of diseases of bacterial origin both superficial and deep-seated, with results which have in many cases been surprisingly successful; cases which had under other methods of treatment either become worse or had not improved at all making a rapid recovery. This has naturally led to an inquiry as to the reason of the improvement, and consequently as to whether the X rays possessed any specific germicidal action.

Close observation and examination has led to some complexity of opinion upon this point, some observers being of the opinion that the X rays do not possess any such power, whereas others are equally of opinion that the germicidal action of the rays is undoubted. It would be difficult to find opinions more diverse than these, but, nevertheless, the adherents to each of these conclusions have some good reason for their assumption. Those who declare that the X rays are non-germicidal bring evidence to show that germs which were present before irradiation are still there after that operation, and those who are of opinion that the rays possess a decided germicidal property give equally substantial evidence in support of their contention by producing cases which have become sterile of the infecting micro-organisms after treatment.

Upon the principle that there is no result without a cause, there must be some good reason why evidence so contradictory can be produced, for it is certain that investigation upon thoroughly scientific lines has led to the conflict of opinion, and it appears probable that the investigations have been made in different directions. The one set of investigators have based their claims upon findings made as the result of experiments and observations of the action of X rays upon bacteria in *inert* or dead *media*, whereas the other set have based their claims upon the result of the action of the rays upon micro-organisms in *living animal tissues*—a distinction of the utmost importance and one which will reconcile these opposite opinions and prove them both to be true.

It will, therefore, be interesting to inquire into the effect of X rays upon bacteria first in *inert media* and then in *living animal* tissues. We shall then see that the action of X rays upon bacteria in inert media is not germicidal, and we shall also see that the absence of bacteria in living animal tissues after irradiation is not due to the lethal action of the X rays but to the stimulation of the living animal tissues leading to increased phagocytosis and so to the disappearance of the micro-organisms, but that the phagocytosis is materially aided by the action of the X rays upon the bacteria.

RESULTS OF EXPERIMENTS

To this end we will now inquire into a few experiments.

If fresh plate cultures of tubercle bacilli be exposed to the X rays in such manner that one-half of the culture plate be protected from the action of the rays by means of a lead sheet, it will be found that upon the portion of the medium covered by the lead growth of the bacilli will have taken place, whereas upon the exposed half no such growth will be evident, although the bacilli placed there will still be present. Again, if developed colonies of bacilli be exposed to the X rays they will not be destroyed by the exposures, but no further development will take place.[2]

It is evident from these experiments that the micro-organisms are not destroyed by the rays, but that their growth is stopped, and it has been found impossible by any ordinary long exposure to high vacuum tubes to kill growths of bacilli by X rays.[3]

Bergonié and Mangour demonstrated that they were unable to destroy the virulence of tubercle bacilli by exposing sputum containing them to the X rays, for after an exposure of six hours to the rays at a distance of 20 mm. from the tube the tuberculous sputum when injected into guinea-pigs caused acute miliary tuberculosis in all the animals injected.[4]

This subject has claimed the attention of many bacteriologists, and from the results of their work there is undeniable proof that the X rays themselves have no germicidal properties and that the germicidal influence of the X rays themselves upon the bacteria is practically nil. We have thus seen that the germicidal action of the X rays upon bacteria in inert cultures is practically negative; the effect of the rays upon micro-organisms in living animal tissues, however, is quite different.

Pusey and Caldwell[4] say that when a suppurating ulcer is exposed to the X rays unmistakable evidence of interference with the growth of the pus organisms is shown. The discharge changes from pus to a sero-purulent and then to a sero-fibrinous fluid, and soon the ulcer becomes clean and free of contamination with pus organisms. This drying up and cleaning of infected ulcers has been noted by many observers, and it occurs regardless of the character of the ulcer, dirty septic ulcers of carcinoma, syphilis, and lupus become clean and sterile under the influence of X rays alone without the use of antiseptics in localities where cleanliness cannot be maintained; it is, therefore, clear from this cleaning process that the micro-organisms responsible for the septic conditions have been destroyed as a result of the exhibition of the rays to the living animal tissues.

In order to demonstrate the effect of tubercle bacilli in living animal tissues, experiments were made upon eight guinea-pigs, which were inoculated in the inguinal region with tubercle bacilli. Three of them were then exposed to the X rays, and all three remained well, whereas the five guinea-pigs which were not exposed to the rays all developed tuberculous diseases at the point of inoculation.[5]

Pusey and Caldwell have emphasized the fact that organisms can be destroyed by exposures to X rays when situated in living animal tissues, whereas the same organisms in inert cultures are not destroyed by the X ray exposures, proving that it is not the influence of the X rays themselves, that causes their destruction, but that the living tissues, doubtless under conditions of activity excited by the X rays, play an important part in this germicidal process, and that it may well be imagined that this process is in the nature of stimulation of the cells, which are rendered thereby better able to take care of themselves against the invasion of the organisms, and that this effect on bacteria is caused by increased phagocytosis.

CONCLUSIONS

It might well be said that if the increased phagocytosis is due to increased stimulation of the tissues, what proof is there that the X rays play any part different from that of any other stimulant applied to the region?

* A paper read before the London Dermatological Society. Reported in The Lancet.

[1] Münch. med. Wochenschr., 1898, xlv., 773; 1902, xlix., 402.
[2] Comp. rend. Soc. Biol., 1897 (Série 10), iv., 689. Archives Röntgen Soc., 1900, v., 3.
[3] Bull. Acad. Med., 1897 (Série 3,) xxxiii., 66.
[4] Pusey and Caldwell: Röntgen Rays in Therapeutics and Diagnosis, 1904, 290.
[5] Semaine Médicale, 1896, xvi., 266.

The answer is that if tuberculous glands, such as are commonly met with in the cervical region, be subjected to the influence of the X rays, they will in course of time atrophy and become sterile of tubercle bacilli, whereas glands of a similar nature exposed to stimulation of other kinds, such as fomentations, poultices, iodine, etc., do not atrophy and become sterile, but rather increase in size and bacillary virulence.

We thus see that the phagocytosis, encouraged by the applied stimulation, is not alone sufficient to prevent infection; it follows, therefore, that the X rays must play an important and specific part in the prevention of the infection by and in the destruction of the bacilli.

We found that when the tubercle bacilli were exposed to the rays they did not form colonies, and we also found that developed colonies exposed to the rays did not grow, that the bacilli were not destroyed in either instance, but that their increase and multiplication had been inhibited.

This, then, is the reason why inoculated guinea-pigs when subjected to the influence of the X rays do not develop tuberculous lesions. The phagocytes are equal to the task of destroying the germs inoculated into the animal if the germs are deprived of their power of rapid reproduction, but if their reproductivity is not inhibited the phagocytes are unequal to the task of dealing with the ever-increasing invading forces.

We may, therefore, conclude that the effect of X rays upon diseases of bacterial origin is that they have not any germicidal powers, but that they have a decided inhibitory effect upon the reproduction and increase of the germs, and that they produce stimulation of the living tissues leading to an increased phagocytosis, which is capable of destroying an unreproductive colony of micro-organisms.

A Ghost of the Past*

Ancient Engine in Use Until Recent Years in England

THE interest that was displayed in the description of the old colliery pumping engine, contained in Mr. W. T. Anderson's paper, read some time ago to the members of the Manchester Geological and Mining Society, shows that there exists among engineers a feeling of veneration for these old relics of steam engineering practice, many—too many—of which have been permitted to end their days of usefulness ignominously, by relegation to the scrap heap. It is a matter for regret when such old engines are destroyed without some record being kept of their origin, peculiarities and duties,

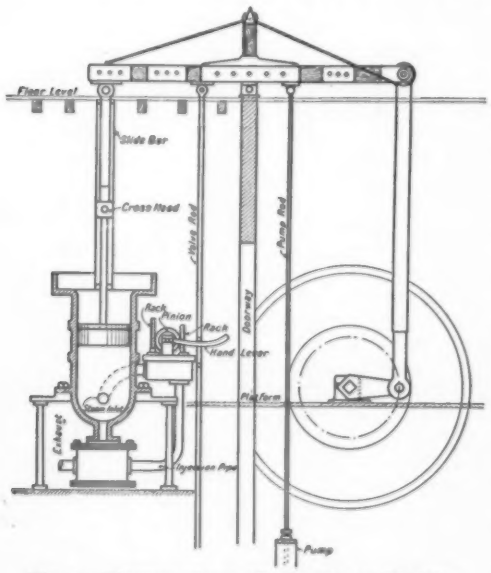


Fig. 2.—Diagram of an ancient engine at Madeley, England

for if present-day engineers find little that is of service to them in their construction, they will at least learn how our ancestors overcame difficulties by means of rude and inexpensive appliances.

The engravings on this page illustrate an old colliery engine and winding gear, which until a few years ago was still doing useful work at a mine belonging to the Madeley Wood Company, at Madeley, Market, Shropshire. This is, no doubt, one of the engines referred to by Mr. Henry Davey in his paper read before the Institution of Mechanical Engineers in 1903. The author said that "at that time—1780—there were sixteen large engines at work in connection with the coal works and furnaces of the Coalbrookdale concern at Ketley, Dawley, Madeley, and Coalbrookdale, chiefly

*The Engineer.

Fig. 1.—An old English colliery hoisting plant

for pumping." A photographic reproduction of a winding engine built at Coalbrookdale about 1790 was included in Mr. Davey's paper, from which it seems certain that the engine under notice was by the same designer. It is of the atmospheric type, with a single open-ended vertical cylinder, 3 feet diameter by 4 feet stroke. Steam for driving was supplied, latterly, at about 4 lb. pressure per square inch, by means of the egg-ended boiler shown immediately to the right of the engine-house in Fig. 1, but was formerly obtained from the haystack boiler seen on the extreme right-hand of this view. The building in which the engine is housed can lay claim to no architectural pretensions. It has two storys and a protruding platform extending out from the upper floor and giving access to the outer end of the beam. A singular feature about some of these old beam engine-houses is the lack of "elbow room" provided. Although situated in a place where a few square yards of land, more or less, was of the least possible consideration, the engine-house at Madeley is very cramped, and although a cast iron staircase is provided between the two floors, the engine driver would have to be of slight proportions to obtain access to the valves in the foundation.

The cylinder is a single casting shaped somewhat as shown in the sketch—Fig. 2—and is carried on four cast iron pillars bolted to the foundation of the building. The piston is of cast iron packed with hemp, which is secured by a junk-ring and set screws, the packing being kept steam-tight by the introduction of a solution of cow-dung on top of the piston. We have not been able to ascertain what the particular merits of this solution are for the purpose to which it was applied, but it was certainly very generally used. The employment of water on top of the piston would have the advantage that in case the piston packing was not tight the leakage of water past the piston would help somewhat in producing a vacuum below it. The base of the cylinder is hemispherical and there are two branches, one somewhat above the bottom, for the steam inlet, and the other for the admission of condensing water and exhaust alternatively. To this latter branch a box or hot well——Fig. 2—built up of cast iron plates, is bolted, in a somewhat similar manner to that employed in the atmospheric pumping engine at the Moira furnaces, illustrated in Mr. Davey's paper. We were unable to investigate the internal arrangement of this vessel, but it has three branches, one on top for connection to the cylinder, and one on each end, with a self-acting flap valve for the exhaust. Considerable importance attaches to the hemispherical shape of the cylinder base. This enabled the water of condensation to be completely drained from the cylinder prior to the admission of the steam on the next working stroke. In some of the old engines with flat-bottomed cylinders the fuel consumption was unnecessarily high, owing to much of the steam being condensed as it entered the cylinder by coming into contact with water having an exposed surface equal to the area of the cylinder. Two vertical cast iron slide bars—Fig. 3—extend from the top of the cylinder to the floor level above. These form the guides for the piston-rod crosshead, the rubbing surfaces of which are of wood. Two vertical wrought iron straps connect the crosshead to one end of the beam above. The beam is of oak, strengthened by cast iron side plates and tie-rods extending from each end to a cast iron cap secured on top

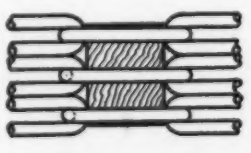


Fig. 4.—Hoisting chain

of a central oak upright which in turn is driven into an iron casting bolted on top of the beam. The beam oscillates about a trunion, carried by brackets on the walls of the engine-house, and from the other extremity is pivotally suspended a long and heavy cast iron connecting-rod, which in turn drives a crank on a square shaft forming part of the winding gear, which is seen in Fig. 1. Two other vertical rods are pivotally suspended from the overhead beam, one outside the house, and shown in Fig. 2, actuating a pump which supplies water for condensation and boiler-feeding purposes, to a cast iron tank on the top floor. From this tank the water flows by gravity to the engine cylinder and to the boiler for feed, the head of water being sufficient to overcome the pressure of 4 lb. in the boiler. The pump is of the bucket type. The other rod referred to is inside the building—see Fig. 2—and serves to actuate the steam and water valves, of the plate and pin type, which are situated between the cylinder casting and the doorway on the first floor—Fig. 2. These valves are actuated, jointly, by means of a toothed pinion and racks, the movement of a lever by trip mechanism or by hand in one vertical direction opening the steam valve and closing the water injection valve simultaneously, or *vice versa*. This part of the mechanism is probably not as old as the engine itself, and is very similar to that used on the Moira engine above referred to. To make one revolution of the winding drum seven working strokes of the engine are required, and these, we were told, were made in three minutes. When the cages were reaching the end of the haul the driver had to stand by and shut off the steam by means of the throttle valve, and the reversing of the engine was similarly performed by hand. Warning of the approach of the cages to the top or bottom of the pit was given by worm gearing actuating a gong in the engine-house. The vertical rod above alluded to, being suspended on the cylinder end of the beam, cut off the steam and admitted water at the top of the upward stroke and on the downward stroke shut off the water and again opened the steam, but the tripper mechanism could be thrown out of gear and the operations carried out by hand, if desired. The upward movement of the piston was, therefore, brought about partly by the pressure of the steam under the piston, equivalent to about 1¾ tons, and partly by the weight of the solid cast iron, connecting-rod, which is probably several tons; while the downward stroke was effected by the pressure of the atmosphere above, equivalent to nearly 2½ tons with a vacuum of 12 inches. The beam is 14 feet long between the centers of the piston link connections and the connecting-rod. At the connecting-rod end,

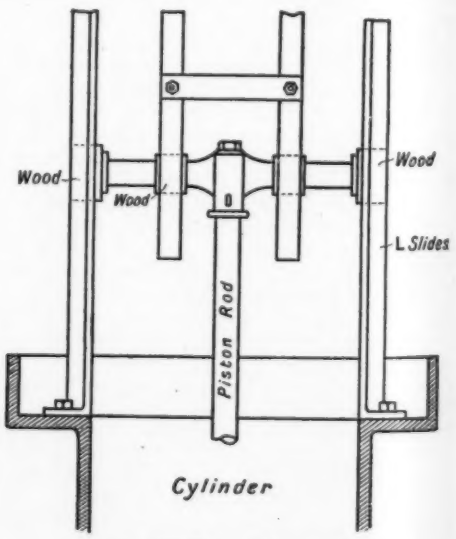


Fig. 3.—Slide bars and cross-head

two cast iron plates are bolted to each side to form a fork, the plates being connected by a wrought iron gudgeon pin, about 4 inches diameter, and held in position by a split pin. The end of the cast iron beam is lined with brass secured by keys and cotters.

The winding gear is operated by means of a spur pinion on the square shaft, meshing with a wheel on the drum shaft, a large cast iron fly-wheel is secured on the first motion shaft and a brake drum on the second motion shaft. Two winding drums are provided for the two pit shafts, one for letting down a cage, while the other hauls up the other. As the mechanism was designed and constructed long before wire ropes had been thought of, chains were employed. These are made of wrought iron in triplicate, as shown in Fig. 4, and are connected together by means of stout oak wedges driven through the alternate sets of links.

Ferro-Concrete Ships*

Interesting Developments in a New System of Construction

THE recent experiments in the construction of ferro-concrete vessels have aroused an unusual degree of interest, and shipyards for the construction of such vessels have been, or are about to be, started in several places. Reinforced concrete vessels are by no means new. During the last six or seven years several have been constructed experimentally, but little or no progress on a commercial scale has so far been made. It is probably only the shortage of tonnage resulting from the war and the difficulty of obtaining the ordinary raw materials for shipbuilding, which have caused engineers to take up the question in earnest.

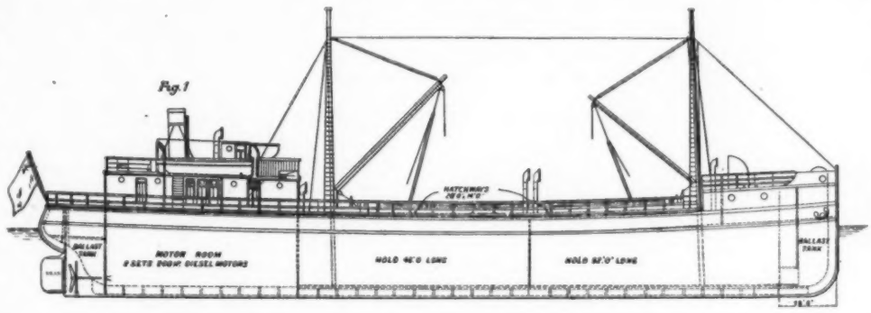
It may be of some interest to mention a few isolated examples of ferro-concrete vessels, built within the last five or six years. In the autumn of 1911 one of the Danish Boards of Engineers commenced the building of a barge or lighter of the following dimensions: length, 47 ft. 6 in.; breadth, 13 ft. 10 in.; and depth, 5 ft. 10 in.; carrying capacity, about 27 tons d. w. It was built of ferro-concrete, both the design and the construction being in experienced hands. It was taken into use in the following spring. In the design much attention was paid to the protection of the bows and sides against impact, heavy fenders of wood being attached to all the exposed places by means of bolts cast into the reinforced concrete. The inside of the vessel was also effectively protected by wood. This lighter has proved quite satisfactory, and no drawbacks have been found to attach to the material used. Some time previously the Danish Royal Dockyard had ordered some ferro-concrete pontoons for a floating bridge. They served satisfactorily for some time, until one night, during a heavy gale from the north, which caused considerable sea in the outer harbor, a good-sized hole was chafed in one pontoon by a piece of floating timber between it and the pierhead, with the result that the pontoon was filled with water and sank, carrying down the other pontoons and the entire bridge. At about the same time the dockyard built some ferro-concrete pontoons for a pile-driver float. These have proved satisfactory. They are protected against chafing by wooden fenders on the sides and other exposed parts. The report from which the above details have been obtained states that experience has shown that ferro-concrete, rightly designed and constructed by men skilled in this special branch, may prove a reliable material for floating constructions, including vessels, provided that they are effectively protected against impact and chafing, etc.

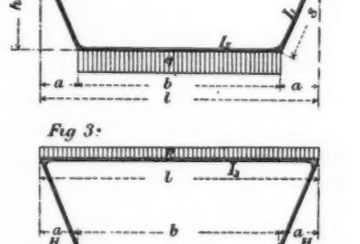
In Germany and Holland several small craft have been built of ferro-concrete during the last few years, and quite recently lively interest has been taken in the matter. In Hamburg a ferro-concrete lighter was taken into use in the coal harbor some three or four years ago; the bottom, the sides, the frame, and all the ribs were of reinforced concrete. It comprised some small water-tight compartments, but the cargo space was entirely unobstructed. The more exposed portions were also in this case protected by broad wooden fenders built into the concrete.

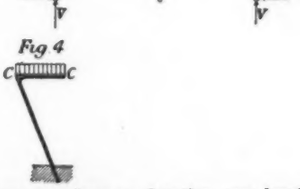
A Stettin firm built a motor boat of ferro-concrete some five years ago. The vessel was divided into four compartments by bulkheads, which also served to stiffen it. The motor rests on wooden beams, which are attached to a concrete foundation. It is of the two-stroke type, and of 5 h. p. This vessel has been used as a pleasure boat, and apparently has given satisfaction. Also in Holland ferro-concrete boats of modest dimensions have proved efficient. The first ferro-concrete motor boat on the Boden lake was put in the water at Constanz some five years ago. In Russia the use of ferro-concrete vessels for coasting and river traffic has also commenced, a French vessel built at St. Rafaele being accepted as a model. Russia is rich both in cement and sand, in addition to which ferro-concrete vessels are fireproof, which is considered a great advantage in a country where fires on board the river craft are stated to be frequent. For the transport of naphtha products, boats built of this material are therefore generally considered particularly well adapted.

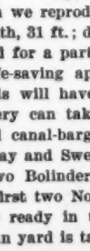
The instances referred to above are all small boats, which, though apparently satisfactory enough, did not lead to anything approaching a regular industry. This, however, has now been instituted. We have already several times referred to the subject in connection with the Norwegian yard exploiting the Fougner patents. In Sweden one cement-working concern has constructed some barges, used for transport in their own business, and another similar firm is also about to make a start in the same direction. In Denmark, too, the matter has now been taken up.

The Fougner company at Moss has recently obtained the necessary permission from the Norwegian authorities to commence the construction of two ferro-concrete vessels without waiting for the final report from the Concrete Ships Committee. The two vessels are of respectively 600 and 1,000 tons, and the fact that the Government has given this dispensation shows that a considerable interest must be taken in this new material for shipbuilding. The vessels in question will have four watertight bulkheads, double bottoms of ferro-concrete, and water-ballast tanks fore and aft. In deference to the requirements of the authorities these new vessels are built about 20 per cent. stronger than the yard would normally make them, which, however, does not mean an increase of 20 per cent. in the weight of the vessel. The dimensions for the 1,000 tons boat, of









which we reproduce an elevation, are: length, 166 ft.; breadth, 31 ft.; depth, 18 ft. The authorities have stipulated for a particularly ample equipment with regard to life-saving appliances, and the first ferro-concrete vessels will have to undergo special tests before the delivery can take place. The boats resemble the so-called canal-barge type, which is well known both in Norway and Sweden. The propelling power is supplied by two Bolinder crude oil motors of 200 h. p. each. The first two Norwegian concrete vessels are expected to be ready in the course of October. Another Norwegian yard is taking up the construction of good-sized ferro-concrete vessels, and intends to make a specialty of standard types.

In one respect Denmark seems to have taken the lead in connection with ferro-concrete shipbuilding, inasmuch as official rules have been laid down for designing such vessels; neither Norway nor Sweden has, so far, found it convenient to issue such regulations. The Danish rules have been worked out by the well-known expert in ferro-concrete matters, Professor E. Suenson, of the Polytechnical High School, Copenhagen, who is a member of the committee on ferro-concrete vessels. The rules apply to the building of small flat-bottomed vessels of ferro-concrete.

Basis for Calculations.—The dimensions are to be fixed on the basis of the Union of Danish Engineers' rules for structural work in ferro-concrete, subject to the following regulations:

The bottom and sides must be at least 7 cm. (2.8 in.) thick. Flat surfaces less than 8 cm. (3.2 in.) thick are to be considered as simply supported unless so reinforced as to be capable of withstanding bending moments in both directions.

The tensile stress on the metal must not exceed eight tons per square inch; the compressive stress on the concrete must correspond to a factor of safety of seven, or a maximum of 800 lb. per square inch. When the calculated sheer stress on the concrete exceeds one-tenth of the compressive stress provision must be made for taking it wholly on the metal reinforcement.

In calculating the strength of the hull the vessel is assumed to be riding on a trochoidal wave of length L, equal to the length of the vessel between perpendiculars and with a height equal to one-twentieth of the length. The cargo compartment is taken to be fully laden with a homogeneous cargo. The calculation is to be made both for the condition when the vessel rides on a wave crest and when it lies in the trough.

The transverse strength is provided for on the hypothesis that the vessel is fully laden, but in such a manner that the cargo is evenly distributed over one half the total area of the hold while the other half is free. The maximum external pressure to be provided for is that due to the draught $+\frac{L}{-40}$, where L is the length between perpendiculars. No allowance is made for any distributing effect of the longitudinal girders. The bottom of the hull is taken as a beam subject to a uniformly distributed load q and to the bending moments due to horizontal thrusts H applied at the point at which the sides and deck girders intersect (see Fig. 2). The direct action of the water pressure on the sides is ignored, but is provided for in fixing the value of H, for which the following formula is adopted:—

$$H=\frac{q}{4}\frac{b}{h}\left\{\frac{b}{3+2\frac{I_2}{I_1}\frac{S}{b}}+2a\right\}$$

Here q denotes the uniform load per square foot on the bottom of the hull, whilst I_2 and I_1 represent the moments of inertia of the cross-sections of the bottom and sides respectively.

The side ribs are investigated for the same two cases of loading as the bottom plate, and also for the cases represented in Figs. 3 and 4.

The deck is dimensioned for a load of not less than 700 kg. per square meter plus its own weight.

The through deck girders are assumed to form in conjunction with the side ribs a two-hinged frame, the hinges being at the points where the center lines of the side ribs intersect the center line of the bottom.

The stringer plate c—c (Fig. 4), as a horizontal girder, must be able to transmit the horizontal pressure H (Fig. 1) to the through-deck girders at the end of the hatch. These deck girders are dimensioned for the horizontal pressure represented in that figure and also for the value of H corresponding to Fig. 2.

Watertight partitions are required to withstand water pressure from either side full up to deck level. Safety against local damage by collision is to be provided by giving the vessel such a shape that under normal conditions it can only be hit above the water-line. After completion the hull is to be painted up to the load-line with asphalt, coal tar or similar waterproofing coating.

*Engineering.

Some Latter-Day Problems of the Foundry*

War Conditions and New Phases of Long Familiar Questions

By Dr. Richard Moldenke

Few industries in the world are so dependent upon quality in raw materials of ordinarily low cost as is the foundry. When the present cataclysm shall have passed and things become normal, the foundryman will feel as if he has awakened from a nightmare. While he shares with most of the industries the shortage of labor, he has to draw upon a division of skilled workmen that cannot be trained in a week or a year. Furthermore, unless the iron and fuel bought is of proper quality, he starts with a handicap making the production of high grade casting a sheer impossibility. The raw materials must be "good" and not merely "near good."

Since, however, results are wanted and not complaints, a few thoughts bearing upon the present foundry situation may not be amiss. What is given here is based upon the observations of the writer in his professional work since the problems of the foundry have become acute. When called in to diagnose the cause of bad casting as entirely apart from high shop costs, the first thing that strikes the close observer is the general deterioration of most of the raw materials received in the foundry. Since it is almost impossible to make rejections and buy elsewhere, it becomes a problem of what to do under the circumstances. The items may, therefore, be taken up one by one.

POOR MOLDING SAND.

Probably the first trouble experienced had to do with poor molding sand. Whether the foundries suddenly decided to lay in big supplies, or the sand pits had become bare of the cream of this essential foundry raw material from competition during hard times, the fact remains that as the rush came on everything went. Shiploads and trainloads of molding sand arrived at destination, were stocked, and in regular course this new sand arrived on the heaps. Very soon the casting showed the effect of poor bond, the metal cutting and the heat destroying the fine surfaces above the rising iron in the mold; copes dropped, etc. Investigation was usually started too late and the sand heaps were in exceedingly poor condition. The only thing that could be done to save the situation until arrangements for better sand could be made was to throw clay wash on the heaps regularly to work in new bonding material. Where possible, the foundryman was advised to go to the sandpit of the dealer and select his material even if he had to pay a bonus.

REMEDIES.

This situation, prevalent in most parts of the denser foundry territory of the country today, points to two lines of activity: first, the study of molding sand as received and as in daily use; second, the improvement of the sand at the pit, or, if necessary, entry into the manufacture of artificial molding sands.

The origin, functions and testing of molding sand are now pretty well understood, the latest textbooks giving light upon the subject. Wide-awake foundrymen can, therefore, have tests made on the bonding power of their sands as shipments come in, and also of the separate heaps on the floor. A limit of strength must be fixed below which the heaps may not be allowed to drop. Further, specifications should be made requiring a given minimum of bonding value in new sand even if such sand commands a premium. Molding sand is one of the fundamentals of the foundry industry and one had better commence right rather than have a defect follow all through the subsequent operations. As stated above, the addition of a very fat and refractory clay to the heaps in the foundry is about the only means of correcting them until a better grade can be brought on. It is to be hoped that the sand merchants may give the matter attention before the foundrymen do this for them, otherwise it will be only a question of time when an artificial product finds a footing in the industry. The foundryman cannot afford the loss of casting which he can directly trace to outside sources.

HIGHER SULPHUR AND OXYGEN.

Next would come the metal problem. On the whole, the difficulty is not so much one of deterioration of pig iron owing to the rush, as from a different situation. The furnaces are working steadily and fairly well, so that here it is more the price that hurts (and this is loaded upon the customer), besides the heartbreaking delivery problem. The real difficulty, however, lies in the pig-scrap ratio which directly affects the value of the pig iron used. If, instead of taking 60 per cent pig and 40 per cent scrap, the proportions are reversed the same quality results cannot be expected. In spite of the high levels to which all the scrap metals have climbed, there is every temptation to use heavier scrap percentages to cheapen the mixture. Cases with 80 per cent scrap are common today, and indeed the results show it. Even in the case of the scrap varieties there is to be found a variation in prices dependent upon the supplies of the region. In some places car wheel scrap is abundant; in others stove plate can be picked up at reasonable figures. Necessarily, with the pig iron levels existing it would be strange if such chances are not being utilized regardless of the ultimate consequences. The two items of the sulphur and oxygen content in iron castings are, therefore, climbing steadily and will later on confront the industry with disastrous effect.

In view of the above, two items must be watched with the closest attention; namely, the fuel used and the melting practice. When the fuel aggravates the sulphur situation it is bad enough, but if added to this the melting practice is calculated to bring out cold iron, this will mean abnormal sulphur figures besides oxidized and hence defective work from the standpoint of shrinkage, gas holes, cracks, etc.

FUEL DIFFICULTIES.

The fuel problem today is a serious one. Carload after carload of coke is received in foundries with ash up to 14.50 and sulphur near the 1.50 mark. What is the foundryman to do? He may protest, but he gets all sorts of excuses. He is told that others are having no trouble with the coke, which may be a source of satisfaction, but investigation usually shows that the class of work in question had no machining of consequence and could stand defects of a pretty serious nature before rejection would take place. With such coke, advice is difficult. All the foundryman can do is to watch his cupola so that he may get the hottest iron the coke is capable of producing; further, that melting is done at the proper bed level to prevent oxidation of metal, which in raising the freezing point means short "life," poor feeding, gas holes, etc.

RIGHT CUPOLA CONDITIONS.

Perhaps a short review of the cupola conditions necessary for good work may not be amiss here. The position of the bed is the crucial point. Depending upon the blast and cupola cross-section relation, will there be a certain velocity of the gases upward? There will be one bed level for the best results. This is when the air coming from the tuyeres has had its oxygen completely consumed, but in doing this has not yet allowed much of the carbon dioxide formed to become carbon monoxide—with the rendering latent of a lot of the heat. This point is incidentally the position of maximum temperature and is independent of the weight of the bed. It is dependent only upon the height necessary to allow the above mentioned reactions. The best guide the foundryman has in getting his coke bed right, is to time the "first iron." With conditions of charging normal, when putting on the blast, molten iron should be seen to trickle past the tuyeres in about six minutes. As this drops upon the bottom and comes out of the tap-hole attention should be given to note when a stream begins to run over the spout into the ladle or on the floor. This should take place between eight and ten minutes. Then the bed will have been right. If in six or seven minutes, the bed should be raised, and conversely if the first iron comes in twelve minutes or more, the bed must be held lower as coke is wasted otherwise.

POOR PRACTICE RATHER THAN POOR COKE.

Right here, when speaking of "normal charging conditions," many a foundryman is today suffering from poor coke because of his own poor practice. Going about the country many a cupola will be seen in operation the charging door of which is perhaps only 8 ft. above the bottom plate, whereas it should be at least 15 ft. The heat imparted, the iron in the melting process may be divided into three parts: that needed to bring it up to the melting point, the heat necessary for the actual melting, and finally the additional amount to superheat the molten iron to the proper point. In the metallurgy of cast iron it happens that most of the heat is required in bringing the metal to the melting point, or somewhere over white heat. All this heat must get into the iron as it passes from the charging door downward into the zone of melting. It will naturally make quite a difference whether the column of metal and fuel in the cupola is 5 ft. above the top of the bed or 12 ft. Furthermore, when the bed has burned through properly and the cupola has been charged, it also makes quite a difference in the temperature of the first part of the heat whether the fully charged cupola has been allowed to stand an hour or more, or blast is put on at once. With the ash content in coke at about 8 per cent this situation is perhaps not so marked; but when the ash approached 12 per cent. matters begin to be serious.

Hence, the foundryman should observe his practice closely and see whether he cannot increase the height of his charging door, if too low. Also, he should charge very early in the day, if possible, to allow the cupola a chance to warm up for at least an hour, and preferably two. In this way the coke may be high in ash and sulphur and yet give serviceable results. Charging early naturally brings up the question of daubing up the cupola. Unless the brick in the melting zone is chipped off clean, so that a proper contact is established between brick and clay daubing, the latter will not stick when under the high temperatures of the melt. Any slag between brick and daubing will soften and allow the patches put on to slide down. The result is not only a thick, pasty slag and bridged tuyeres, but a further cutting into the lining. Furthermore, it is necessary to use the highest grade of clay for daubing purposes, as the idea of daubing up is to restore the lines of the brick-work, and this cannot be done successfully with inferior clays.

PRESERVING THE LEVEL OF CUPOLA BED.

Granted that the cupola bed is of the right height, the next point is to see that it stays at the right height during the entire melting operation. That is to say, as the top of the bed burns away in furnishing the heat necessary for melting the metal charge upon it, the level must be restored by the intermediate coke charge coming down after the iron has melted away. This intermediate coke charge is a matter of weight and not height, as was the case with the bed, for here it is a question of burning enough fuel to melt the metal over it. Again, as the bed dare not be lowered very much before the ideal conditions at the proper point are spoiled, the iron charge must not be too large. This requires further explanation:—With ordinary blast and cupola cross-section conditions the height of the coke bed is 22 to 24 inches above the top of the tuyeres (it is understood that but one row of tuyeres is used). The oxygen of the blast will therefore vary from maximum at the tuyeres to zero or at least minimum at the top of the bed. Similarly, the carbon dioxide will vary from nothing at the tuyeres to maximum at the bed level, with carbon monoxide just forming. It is quite evident then that just below the top of the bed—say six inches—the ideal conditions will not have been reached as yet, some oxygen being present, the carbon dioxide in lower percentage, and incidentally the temperature not at the maximum. Hence there is danger if the metal has to melt at this low level of cold and oxidized iron. In practice it is not advisable to allow the bed to lower more than four inches.

FORMULA FOR METAL CHARGE.

This at once gives the standard metal charge for any cupola; that is, with the understanding that not more than 4 in. of coke may be burned away each time a metal charge is melted—and this 4 in. of coke of the bed being replaced by the intermediate fuel charge—the weight of metal allowable for each charge will be the amount which can be properly melted by the weight of four inches of coke in that cupola. In practice, everything being right, there is usually ten times as much. Hence the foundryman has only to find the weight of coke filling four inches in height of his

*The Iron Age.

cupola and multiply this by ten to know the standard metal charge he must use. This does away with a big first charge and discussion on big and little charges, etc.

And yet how different things are in actual practice when a comparison is made between the plants one sees or finds described in the technical press. For the same diameter cupolas one foundry may use an 8000-lb. charge of metal and another foundry 3500-lb. In one case the foundryman doubles the first charge, in another he also doubles the first intermediate fuel charge. In nearly all cases more coke gets into the cupolas than the owners imagine. This may be the saving condition where big first charges are used, and considering the class of men employed to attend cupolas such coke charged unnecessarily covers a multitude of sins of poor distribution of metal, mistakes in weighing, etc.

FACTORS IN THE FUEL RATIO.

Unfortunately, however, too much fuel means cold iron just as much as too little, yet it has the advantage of unoxidized metal, which is not the case with a low bed. The importance of getting just the right amount of fuel for the cupola can be seen from the above. Where more than the required amount of coke has to be used to care for poor charging methods it means an abnormal sulphur increase in the castings produced. It also means more ash to be fluxed away, the chances of dirty iron and a higher fuel cost. While it is very poor policy to skimp with the fuel, it is not necessary to throw money away. The foundryman should, therefore, give close personal attention to the charging floor of his foundry and see that the necessary amount of brains is diverted to that department.

The proportion of fuel and metal, given as one to ten, the bed excluded, will of course vary somewhat with the character and heating value of the coke, the length of the heat, nature of the metal charges, etc. The foundryman should watch the scoring of his cupola every day to see whether this is confined to less than a foot, as in good practice, or whether the evidences begin at the tuyeres and run up 3 ft. or more. The metal should also be charged evenly and in sequence of steel first, pig and heavy pieces next, and the lightest material for the top. Such a situation should be self-evident.

AIR FURNACE TROUBLES.

If the cupola is run under difficulties today the air furnace is in a similar predicament. Anything in coal goes, whether the sulphur is up or down, lumps are conspicuous by their absence and the slate to be seen tells of high ash. The mines are evidently being thoroughly cleaned out in preparation of a coming competitive campaign when things are normal again. In addition to coal troubles there are the dearth and deterioration of refractories to face. Firebrick is a scarce article of commerce today, and hence furnaces and ovens are run to the last ditch, with the usual consequences to the castings made. Here the truth of the saying about "the stitch in time" finds its application, for repairs kept up to the minute mean a safe and economical furnace. The same situation in regard to scrap-pig percentages is met with in air furnace practice today as in the cupola, and hence the sulphur is climbing steadily. The low efficiency of the air furnace must eventually bring the open-hearth method of melting into the foundry. While the open-hearth is familiar in advanced malleable practice, the gray iron foundry has tenaciously clung to the air furnace where furnace melting is used at all. But with the excellence in product obtained and at a cost but little over cupola iron the first cost and greater operating skill required will not prevent the eventual introduction. Probably the first foundries to take the matter of open-hearth melting for high class gray iron work up for trial will be the plants forced into making steel castings by their customers. With an open hearth equipment at hand odd heats can be made at any time and cupola and hearth furnace results and costs compared.

THE ELECTRIC FURNACE GIVES PROMISE.

On the credit side of the rather gloomy situation for the foundry may be placed the rapid introduction of the electric furnace—the only method free from pig-scrap proportions, high sulphur stock, oxidized metal and bad fuels. While it is not yet applied commercially for gray iron casting work, the elements of cost are being learned, as also the many minor kinks every process seems to embrace. The largest amount of heat to impart to the metal being that up to the melting point there is no reason why this should not be applied in a soaking pit, whence the charge can be transferred into the electric furnace for melting, super-heating and final purification. With the knowledge gained while perfecting the electric steel casting process the gray iron or specialty iron foundry should benefit greatly thereby eventually.

If there is any time for the introduction of molding machinery it is now. Wages are so high and conditions comfortable that the men themselves see the desirability of machine work in view of the scarcity of labor. The plants making this line of machinery cannot fill their orders fast enough, but, in spite of this, there is a gradual improvement in plant equipment noticeable in this direction. With the increasing solidity of the machines themselves and the attention being given by the makers to the peculiar problems of the foundryman mutual benefit is resulting.

The foundryman, therefore, must put up with his troubles as best he can and be positive that his end of the business is up to date. He can then, at least, do as well as the next man. If his own practice is poor it is quite certain that the present difficulties will put him in a very bad position with his customers for the day when things become normal again. He must live from hand to mouth, as it were, doing his share as best he can and at the same time keep up his courage to face the great readjustment bound to come sooner or later.

German Engineering from Within

MR. SIDNEY SMITH, of Pipe Motors (England), and formerly of the Sheffield Simplex Company, has contributed an interesting article to a recent number of the *Monthly Review of Modern Machine Shop Practice*, which is published by Alfred Herbert, Ltd., of Coventry.

The subject of the article is "German Engineering from Within," and it was written in the light of experience gained by the author during three years' experience in a German engineering works—as a matter of fact, at the Metallurgique Motor Car factory in Berlin, a branch of the Belgian firm.

Mr. Smith occupied the important post, to use the German's idea of the right English expression, "chief konstructor"—actually, chief designer. Mr. Smith says:

The factory was splendidly equipped, from a plant point of view, clean as a new pin, and as orderly as a row of them on a card. Every German is automatically orderly, clean and methodical; he learns that in the Army, and his work and results show it in the factory. It is a mistake to speak of "dirty" Germans, unless referring to their morals or minds. It was not that we had an abnormal number of cleaners and laborers about, but the men themselves kept order. Nothing was ever lying about that was not being actually worked upon.

The interesting feature of Mr. Smith's impressions is the curious personal interest of the average German workman in the welfare of the firm as a commercial proposition. He would, on occasion, go out of his way to save the firm time and money, even when it benefited himself but indirectly.

"Everything that could be jigged was jigged, but there was never any tool-room finish on the jigs, they were just accurate, and very often the idea and work of the mechanic himself 'to cut down time.' Think of it, the men themselves labored and strove to cut down the time so that goods might be produced cheaper!"

One does not blame the British workman for wanting to make all the money he can at the moment, but there is no doubt that if at times he used a little more foresight it would pay him well. In the palmy days of peace a business enterprise may be made a success or a failure according to the loyalty or disloyalty of the men, and in normal times, with its surplus of labor, the closing-down of a factory is a very serious thing for the operatives.

Mr. Smith gives a concrete example of one of many hundreds of cases of the kind with which he met.

"Our clutches were internal expanding metal to metal ones. I forget the assembly piece-work price, but the man who did this work called me one day to see an assembly jig he had designed and made with the approval of his foreman. He had rigged it up out of bits of odd steel and bolts, and cut the time of assembly in half. As to money, he asked for and was given, say, three marks, where he had previously had five, and the firm saved two. He made more money and got additional work to do, and his productive power was increased about fifty per cent."

Further, Mr. Smith says:

"How is restricted output to stand against this? How are we to stand up against it except by copying these very wise proceedings and beating their brains—which is not difficult?

"Please do not imagine Berlin workmen were badly paid. Work was abundant and the money good. . . .

"They were out to beat Britain and the other countries in the markets of the world, and intelligent coöperation, goodwill, and give-and-take amongst them was very rapidly doing this, owing largely to our myopic methods."

Later again he says:

"It is the output that counts—the number of things you sell and get the money for—and well these Germans know it, from the most stupid of directors down to their shop-boys.

"Fixed rates and methods—well, we had none. Methods were there as starting points, to be improved from day to day, and costs cheapened. All strove for this from above downwards; nay, I will say from below upwards; but, and this is important, the men were treated generously, as a whole. . . .

"The men were regarded as colleagues by those above, and not as mere machine-minders or fitters to be hired at a given rate, and driven. Of course, the whole thing resolved itself into one of 'attitude of mind.'"

Commenting on the introduction of improved methods of production, a matter on which the British workman is always suspicious on account of possible reductions in piecework prices, Mr. Smith says:

"There was a note of thoroughness and mutual help and interest all through the factory.

"For instance, a difficulty would arise, and those concerned would discuss it on the spot; the workman, or men, doing the actual work would join in, and very often it fell to their first-hand knowledge to suggest a solution.

"The foreman did not resent the man's joining in, he welcomed and expected it, and many times have I seen that really the only two men in the discussion were the chief and the workman concerned. Decisions arrived at in this manner are usually right, because they have a firm foundation on the underlying facts."

On the question of German versus British workmen, taking each on their merits, Mr. Smith says:

"Man for man, in brains and initiative, our men can beat them all along the line, but I fear the German is generally more industrious, keener on his job, broader in his views, more determined to succeed and supply exactly what is wanted, be he workman, foreman, staff official, manager or director, and more alive to the value of mutual trust and help."

On the matter of labor-saving machinery, Mr. Smith says:

"The cry in Berlin was for machines, always machines, and more machines, anything to cut cost and speed up output, and when the firm had not the money the banks provided it."

On the all-important difference between British and German financial methods, as operated by banking firms, Mr. Smith says:

"In Germany, the banks usually have a director on the board of big concerns, and take an intelligent interest in all their clients. They back orders and opportunities as fast as they come along and can be obtained. They provide money or credit for material and up-to-date plant, and share in the resulting profits from the orders executed.

"They don't ask to see twenty shillings before backing to the extent of ten. They merely use their intelligence, and require to see orders and opportunities.

"Our existing methods are a tremendous handicap to our engineers in competing with Germany. Ready capital or bank credit mean material to go at, at the right moment, up-to-date plant, good deliveries and good terms to offer customers."

There is not the slightest doubt that many a leaf can be profitably drawn from the German's notebook. He has done much to teach us how to produce an air service and a colossal army. We have derived much instruction from him regarding the employment of frightfulness and the logic of war, and to refuse to crib manufacturing tips from him would be criminal.

Doubtless Mr. Smith's frank admiration of German business methods will make him unpopular among manufacturers of what he himself calls "our old invincible 'my father did it before me' type, to be met with in such abundance in England," but his open and unprejudiced statements should be of high value to the young generation of manufacturers and works' managers whose mission in life it is, or should be, to oust these old fossilized manufacturers from the pinnacles of success on which they have been placed by their fathers' methods.

Formation of Aniline from Ammonia and Benzene at High Temperatures and in Presence of Contact Substance

MEYER and Tanzen (this J., 1913, 1060) have stated that aniline is formed by the action of ammonia on benzene at 550° C. The author, however, finds that ammonia is without action on benzene in a porcelain tube until a temperature of 700° C. is attained, when a trace of aniline is produced. In presence of freshly reduced iron, copper, or nickel, somewhat larger amounts of aniline were formed.—*Note in J. Soc. Chem. Ind.* on an article by J. P. WIBAUT, Berlin.

The house wren—the commonest and most widespread of all the wrens—is fond of human habitations and quick to avail himself of nesting boxes or crannies about the porch.

Petulant, inquisitive, mischievous

Impatient and fretful—young wrens insist on being fed over five hundred times a day, and one case is on record of a family which was fed 1217 times in one day.

Chips from the old block

The Wrens*

A Great Family of Popular Songsters

By A. A. Allen, Ph.D., Assistant Professor of Ornithology, Cornell University

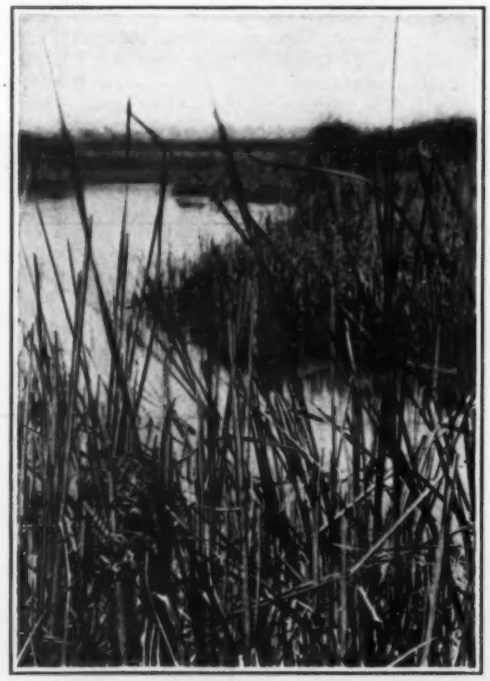
Ages ago there dwelt in northern Africa and along the Red Sea certain tribes of men known as the Troglodytes. They were herdsmen, living entirely upon flesh, and they made their homes in caverns which the ancient sea had gnawed into the rocks. They were hole-dwellers. This alone could have prompted the name of *Troglodytidæ* for the great family of wrens, for surely there is no other comparison between these prehistoric, carnivorous shepherds and the little energetic brown birds which compose the wren family. But *Troglodytidæ* they were christened, because of their hole-nesting habits, and by that name shall they always be known.

There are about two hundred and sixty different kinds of wrens, the majority being found in the tropics of South and Central America. Between thirty and forty are found in the Old World and only fourteen in the United States and Canada.

In spite of their numbers, they are remarkably uniform in plumage, wearing browns and grays in very inconspicuous patterns. They are, with few exceptions, very small birds, seldom exceeding five or six inches in length, with rounded wings and short tails, which they characteristically hold erect or even tilt forward over the back. Their small, plump, brown bodies and their habit of haunting brush piles or sneaking along the ground give them an exceedingly mouse-like appearance. In fact, were it not for their inquisitive ways and their petulant voices, wrens would seldom be seen; but as it is, one cannot pass their retreats without being surveyed from every side and without being the target for their loud fretful calls.

When not alarmed, the male seeks some exposed perch, where, with drooping tail, he gives vent to his exuberance in a voice of surprising volume and sweetness, for, with the exception of the cactus wrens, the whole wren family is famous for the brilliancy of its songs. Even the familiar loud, bubbling, gurgling song of the house wren sinks into insignificance when compared with the bold, ringing songs of the Carolina and canyon wrens or the roundelay of the winter wren. As with most birds, the song is usually confined to the male, but certain tropical species have the delightful habit of singing in duet. L. A. Fuertes, the well-known bird artist, in some pleasing essays entitled "Impressions of the Voices of Tropical Birds," gives us a vivid picture of these birds in action:

"This counter-singing by the female, so far as I am aware, is not generally known among birds, but it is certainly practised by this species (*Heleodytes bicolor*), as well as by all forms I know of, *Phengopedius*, *Henicorhina*, and *Donacobius*. In all these cases the birds sit close together, the male a little above the female, and his song is usually louder and more brilliant than hers. *Heleodytes bicolor* gurgles a loud, clear, oriole-like 'Keep your feet wet.' The female, three inches below and a little to one side, parallels this advice with an evenly timed 'What d'you care?' in perfect unison usually with the reiterated phrases of her mate. *Donacobius* does it somewhat differently, as the female only says 'wank, wank, wank,' while the male sits just above and sings almost exactly like a cardinal, or a boy whistling loudly to his dog, 'hui, hui, hui.' If the male gives only three phrases, so with the female; if, however, the male repeats his whistle a dozen times, the female begins and ends in exact time with him."



A dummy nest of a long-billed marsh wren. All of the wrens build duplicate nests—possibly an indication of a former polygamous habit.

The dummy nest—a peculiarity of the wren

As suggested in the first paragraph, the nests of most wrens are placed in holes, either in hollow limbs, in crevices in the rocks, in crannies about buildings, or in nesting boxes erected for them. Some species, however, like the marsh wrens, build globular structures suspended in the reeds of the marshes, while the cactus wren makes an enormous structure of thorny twigs, placing it well within the heart of a Spanish bayonet or branching cactus.

The energy and industry of wrens find expression for itself in the building of duplicate nests. Not content with having completed one nest, many species, if not all, continue to carry material until half a dozen nests may be constructed. If they are hole-nesting species, every cranny in the vicinity will be stuffed full of sticks. If they are marsh wrens, they will place their globular structures usually within a short radius, although in late summer and early fall, with their energy not yet failing even after rearing two broods of young, they may scatter their nests wherever the spirit seems to move them. The reason for building these duplicate nests, as suggested in *American Forestry* for December, 1916, probably had its origin in the effort of the male to secure more than one mate, and indicates that the wren progenitors were

By Courtesy of *American Forestry*.

Short-billed marsh wrens would seldom be seen if they were content to creep around the tangled sedges, as is their usual habit—but at anyone's approach they climb the tallest reed in the vicinity and rebuke him for venturing into the marsh.

Guarding the marshes

normally polygamous. That house wrens, and possibly others, still are polygamous when opportunity affords; we now have considerable proof (*Ibid.*)

The irrepressible energy of the wrens likewise shows itself in the size of their families, for the eggs usually number six to eight instead of the three or four of most birds. They vary in color, with the different species, from the pure white ones of the short-billed marsh wren to those of the long-billed species which are so thickly speckled as to appear almost brown.

Wrens are almost entirely insectivorous birds, showing but little selection in the "bugs" they eat so long as they are sufficiently abundant to satisfy their insatiable appetites and those of their numerous young. How plentiful insects must be in order to maintain a wren family and how many pests are destroyed by these birds, one is better able to judge after watching the parent birds feed their young. It is by no means exceptional for them to feed their young from five hundred to seven hundred times a day, while one instance is on record (see *The Auk*, January, 1917) of a single male wren (the female having been killed) which fed its young 1,217 times during the 15 hours and 45 minutes of daylight.

There is but one blot on the name of the wren family: they are exceedingly mischievous. This sometimes results in disaster to their neighbors. I have seen a long-billed marsh wren, for example, perch on the edge of a red-winged blackbird's nest and deliberately peck holes in the eggs. I have found the eggs of Virginia and Sora rails with similar holes punched in them, and Dr. Chapman, in his charming book, "Bird Studies with a Camera," tells of watching a marsh wren, in a similar way, destroying the eggs of a least bittern. The familiar little house wren, likewise, sometimes indulges this egg-destroying habit. I once watched a male house wren

A section of a long-billed marsh wren's nest, showing the heavily spotted eggs. Those of the short-billed species are pure white and other species show all gradations in between.

Eggs of the long-billed marsh wren

Much skill and ingenuity are often required to get some of the larger sticks into the box, yet the house wrens persist in using just such materials.

Getting ready for summer

go from the box where he was nesting to one occupied by a house sparrow, disappear for a moment, and then come out with a sparrow's egg in his bill. This he dropped and watched it fall until it broke on a porch

The bird at its nest in the sedges. This species does not frequent the deep-water marshes, but prefers the sedgy borders or even wet meadows.

The beautiful little short-billed marsh wren

roof below. He then dodged back into the nest and repeated the performance until all five eggs lay in fragments, when he flew to the nearest branch and burst into a triumphant song.

If the wrens practised this habit on house sparrows alone, we could only praise them, but, unfortunately, almost any other birds, particularly hole-nesting species, nesting in the near vicinity are likely to be treated in the same way. It is almost useless to try to attract other birds or to put up bird houses within fifty feet of a box occupied by wrens. Wrens and bluebirds seem bitterest enemies, and where they do nest fairly close together the bluebird is ever on the alert to chase the wren.

The *house wren* is the commonest and most widely distributed of all the wrens, some form of it being found throughout North and South America from Quebec to Argentina. It is uniform dark brown above, faintly barred with black, and brownish gray below. It is smaller than the Carolina wren, which is more rufous and has a light line over its eye; it is larger than the winter wren, which is more heavily barred and has much darker underparts, but it is very similar to the Bewick's wren. This bird, however, has a light line over its eye, as has the Carolina wren, and light spots on the corners of its tail. So similar are all wrens to one another in size and color that it is much easier to identify them by their songs, which are distinctly different.

A long-billed marsh wren at its globular nest hung in the cat-tails of the marsh. The opening is in one side.

A marsh wren at its nest

Both the house wren and the Bewick wren are fond of the habitations of mankind and are quick to avail themselves of nesting boxes put up for them, the house wren from Quebec to Virginia, the Bewick's wren from central Pennsylvania to South Carolina. They can be attracted even to the heart of large cities more successfully than any other birds because the opening in the nesting box need not be larger than an inch in diameter, and this will not admit sparrows or starlings, which, by usurping all available nesting sites, have done so much toward driving the hole-nesting species away from the cities. It is best to place the boxes on poles in the sun or light shade, although the wrens are not so particular in this respect as the other "nesting-box birds," and will take with equal readiness a box on the porch or in the center of tree.

The *winter wren* and the *Carolina wren* are both woodland species, but their breeding ranges do not overlap except in the Alleghenies, for the winter wren is a Canadian species, while the Carolina wren is a southern bird occurring only occasionally as far north as New York and New England. In the fall, however, the winter wren migrates southward, some as far as Texas and northern Florida, and at this season all four kinds, as well as the two species of marsh wrens, may be found in the Southern States.

The *long-billed marsh wren* is the commoner of the two latter, frequenting the cat-tails and sedges of marshes bordering lakes, creeks, or sloughs, where its incessant song is always heard. Even during the hours of darkness, when most birds are quiet, the marshes will often resound with a chorus of marsh wrens. At such times it sounds as if Dame Nature were keeping late hours and had brought out innumerable tiny, ill-working

A bumble bee has here utilized the nest of a marsh wren instead of that of a meadow mouse, as is his custom. A broken eggshell tells of the former occupant—a cell of honey possibilities for the future. The bee constructed an inner roof over the chamber containing the honey cell.

A home despoiled

sewing machines. Often the wrens seem to be carried away by the exuberance of their song, and, springing from the flags, they seem actually to explode upward. With their feathers shaken out, their short wings vibrating, their cocky tails tilted far forward over their plump little bodies, they look like animated cotton bolls.

The *short-billed marsh wren* is much yellower in general appearance than his dark, long-billed brother, and is seldom found in the deep-water marshes, for it prefers the sedgy borders of such or even wet meadows. It is ordinarily very mouse-like in its habits, running about among the tangled sedges, and would seldom be seen but for the fact that whenever any one approaches it climbs at once the highest reed in the vicinity to scold him for venturing so far from sidewalks and pavements. Its song is little more than a repetition of its call, like the sound produced by striking two pebbles rapidly together, ending with more of a grating sound.

In the arid regions of the West dwells the largest and most unwren-like of all the wrens, the *cactus wren*. It is a gray bird with a white spotted breast whose large, retort-shaped nests are one of the most characteristic sights of the cactus country. Its song is the least musical of any member of the family, although it is given in characteristic wren fashion, with the tail drooping and the head thrown back.

In the dry, rock-bound regions of the West, where most bird life is scarce, lives the *rock wren*, whose curious tinkling song is one of the few redeeming features of the desolate rock slides of the mountains.

In the canyons it is the song of the *canyon wren* that so frequently causes the rocks to reverberate with wild ringing notes. The bugler, it is sometimes called, but a tiny bugler indeed, less than six inches in length and so inconspicuous that were it not for its white throat it would escape unseen.

The *Parkman wren* and the *Vigors wren* of the Pacific coast region are the western representatives of the eastern house wren and the Bewick's wren. The common wren of Europe and the British Islands, or Jenny wren, as it is often called, is a species very similar to our winter wren in color, song, and habits.

Building a Complete Cycle of Industries*

What a Railroad Has Done to Develop Its Resources

By Victor V. Kelsey

THE Carolina, Clinchfield and Ohio Railway traverses a portion of Southeastern Kentucky, Southwestern Virginia, Eastern Tennessee, Western North Carolina and South Carolina. This will serve to point out in a general way the geographical location.

It is doubtful if there is any section of the United States that is now undergoing a more rapid industrial development than the Southern Appalachian Region traversed by the Carolina, Clinchfield and Ohio Railway. The extreme engineering difficulties which had effectually discouraged the building of railways and had locked up the natural treasures of this most remarkable section were overcome during the first decade of the present century by the construction of the Clinchfield Railway. Built in the light of modern engineering science, with a rock-ballasted roadbed of easy grades and with modern equipment throughout, the Clinchfield serves the double purpose of unlocking the natural resources of the Southern Appalachian region and of connecting the North with the Southeast by a direct short-line route.

One of the prime considerations that led to the construction of the Clinchfield was the opportunity it afforded to unlock the immense storehouse of power, minerals and the virgin timber.

This undertaking was really a pioneer one, and since the building of the Clinchfield it has done other work of a pioneer nature. It is a leader in the fostering of certain industrial developments new to the entire South. For an example, the first pottery designed for the manufacture of decorated tableware has been built on the line. This is typical of the pioneer industrial development.

The examinations of the natural resources of the region have been and are now being carried out under the direction of experts, thus reducing to a minimum the element of chance in the establishment of industries. This policy further prevents any mistakes in locating plants that are not likely to succeed. This has characterized the industrial development in a chemical way, which for completeness and success has but few parallels in America.

The economic and successful operation of any industry is due quite largely to cheap power and raw materials. With regard to these commodities the Clinchfield territory abounds. The superior quality of the coals from the fields of Eastern Kentucky and Southwestern Virginia, served by the Clinchfield, is indicated both by calorimetric tests, showing upwards of 14,000 British thermal units, with low ash, sulfur and phosphorus, thus the question of cheap power is guaranteed.

The undeveloped water powers tributary to the C. C. & O. Ry. are potentialities of much importance to the manufacturer. The magnitude of these powers vary from a few hundred horse-power up to several thousand, and these can be developed at reasonable costs.

With cheap power, both electrical and steam, and a wealth of raw materials the territory offers superior inducements to the manufacturer.

The building of a large portland cement mill on the line was only undertaken after it had been established beyond reasonable doubt that the necessary raw materials were available of the proper character as regards quality and quantity and that the territory to be served would supply a market for the finished product. This industry has been increased 300 per cent since 1911.

The construction of a plant for the manufacture of hollow tile, terra cotta, and brick was begun only after it was fully proven that the raw materials were suitable in every way. The output has been increased 260 per cent since 1911.

The brick plant is typical of the chemical plants on the Clinchfield, forming another link in the cycle, and fitting in nicely with the cement plant, inasmuch as it adds additional materials of construction.

In addition to the cement and brick the development of other building materials followed in rapid succession, thus filling in the gaps necessary for the further completion of the cycle. Other materials of construction developed include: quick and hydrated lime, sand, crushed stone, gravel, limestone, sandstone, marble, granite, timber and lumber.

Several tannic acid extract plants were located along the Clinchfield, because of the natural advantages offered in the way of cheap fuel, cheap power and an unlimited supply of chestnut wood and tan bark, all of which can be assembled at convenient points.

The spent chips from the acid plants represented a waste, whose fuel value is low and therefore practically worthless; but the chips become of value when used for the production of carbdoard and low grade paper. As a consequence of this, and to help complete the cycle of chemical industries, a large soda pulp mill was erected. This mill will use in part the spent acid chips, but will draw its main supply of raw material from the practically inexhaustible supply of pulp woods in the forests of the Clinchfield. Before the pulp mill was completed its capacity was doubled.

The pulp mill needed hydrated lime to causticize the soda liquors. To care for its needs a large lime and hydrating plant was built. The lime plant draws its limestone from nearby local deposits, and is now supplying the pulp mill with hydrate, and a tannery with lime to be used as a depilatory, thus continuing the cycle of chemical plants. The calcium carbonate resulting after the causticizing of the soda liquors is now finding a market on the Clinchfield which precludes any waste.

Tannic acid is a commodity that will permit of long shipment, but instead of sending all the material off the line, a large tannery was built to consume a portion, and to provide a market for local hides. This same industry uses lime and sodium sulphide as a depilatory. These chemicals are now being manufactured in large quantities on the Clinchfield, making more complete a cycle of chemical industries.

A factory for the production of shoes is now under consideration, which will utilize the unfinished leather from the tannery in the production of a finished article.

The pulp mill needed a bleaching agent. A large chemical plant was built, and is now supplying the pulp plant with large quantities of bleach of a very high grade, making the pulp plant a self contained unit, and adding another link to the cycle.

A large dye plant was built and it needed sodium sulphide for the manufacture of sulfur black. Another chemical plant on the line, in a neighboring town, promptly supplied the sodium sulphide of the proper quality and without delay.

The same dye plant consumes large quantities of coal tar by-products, and to take care of its needs plans are now under way to provide the requirements locally. The residue from the coal tar by-products will not be used in the usual way, but will find another outlet which will permit of producing power at a cost that will rival the cost of power at Niagara Falls. When this is completed, this industry will form a complete cycle, when it is considered the dyes are used by textile mills on the line, and furthermore the textile mills are getting their raw cotton from the fields tributary to the Clinchfield.

The only possible link lacking in this cycle is that there is not at present a full line of fertilizers being manufactured on the line, necessary for increasing the cotton and other crops. This phase of the chemical industrial development is being seriously considered. The necessary raw materials are either on or nearby the line of the Clinchfield, and when coupled with the cheap power available in connection with a ready market, the proposition becomes most interesting.

A large pottery was built to utilize the naturally occurring raw materials on the line, and to further the cycle a large number of modern homes were built for the employees.

To provide the pottery with the necessary raw materials of the proper quality large kaolin refining plants were built, as well as feldspar and silica grinding plants. These industries dovetailing in with one another in a fitting manner.

The vast quantity of hard woods standing in the forests along the Clinchfield represents a potentiality of much importance to the charcoal and wood alcohol producers. The saw mills along the line are wasting a thousand cords of hard woods every day that are suitable for the production of charcoal, wood alcohol and acetate of lime If a plant is built to utilize this enormous waste we have assurances that a charcoal iron furnace will be built, thus completing the cycle for this particular industry. There is now a limited market locally for the alcohol and acetate of lime, but these commodities will stand long shipment, therefore there is at all times a good market for these chemicals, and this is particularly true of the present time.

The above sums up briefly the building and operation of a complete cycle of chemical industries on the Clinchfield. Other chemical plants for which the region is particularly well adapted are: the production of artificial abrasives; the production of nitrogen compounds; the production of calcium carbide; carbon electrodes; bleaching agents; caustic soda; pharmaceutical compounds; organic compounds and dyes; water glass; glass products; ultramarine blue; ferro and non-ferrus alloys and still others which it does not seem hardly necessary to mention here.

*An abstract of a paper read at the Third National Exposition of Chemical Industries at New York.

The Production of Tin

A WRITER in an English publication gives the following interesting facts in relation to the world's production of tin: In the time of the Phœnicians, and long after, Cornwall appears to have furnished the greater part of the world's supply of the metal, and to-day more than half of the total output is produced within the British Empire. This is shown by the output of tin for 1911, the last year for which complete figures are available. The British Empire produced 60,497 tons and foreign countries 54,051 tons. First place is taken by the Malay States with 44,136 tons. Next comes Bolivia with 21,887 tons, followed by the Dutch East Indies with 19,909 tons. Australia produced 6,888 tons, China, 5,958, Siam, 5,928, the United Kingdom 4,870 tons, the Union of South Africa, 2,308 tons, and Nigeria, 2,157 tons. The outputs of Japan and India were respectively 144 and 138 tons. The United States, Portugal, Indo-China, German Empire, Austria-Hungary, Spain and Italy produced outputs varying from sixty tons to six tons.

Soundness of Grain

A SWEDISH agronomist, M. Vallden, has been engaged in researches upon the lesions caused upon grain by the threshing process, with special reference to their germinative value, and consequently their use as seed grain. He found a method of testing grain which is an easy one to apply, and all that is required is to immerse the grain in a 0.4 per cent eosine solution and then wash in water. The red color of the eosine is absorbed only by the fissures of the grain. If there is no color, the grain is in the best condition and it is noted as 0; when the end alone is colored, it is noted as ¼, and for one-half the surface, ½. The whole surface is noted as 1. This method allows of selecting the perfect grains.

Sulphur Mixture for Grapevines

POWDERED sulphur now commands such a high price that there is a search for lessening the amount of it employed for treatment of grape vines against parasite diseases, especially in France; and it has been proposed to mix it with lime. Experiments made in the south region show that its effect is not diminished in this case, and the combination powder also gives a good protection against insects and prevents rotting of the vines. About half and half of sulphur and lime is employed. M. Cadoret states that the good effect of the lime is due to the fact that it dries the surface of the leaves and grapes so as to prevent spores from germinating; second, it has a caustic action against mycelium spores; and third, its adherence to the surfaces aids the sulphur in maintaining itself in place during rains.

Molybdenum and Ferro-Molybdenum*

MOLYBDENUM belongs to the group of heavy metals comprising tantalum, titanium, tungsten and vanadium, which are capable of imparting special properties to steel. It was discovered by Hjelm in 1783; its symbol is Mo; it occurs as a solid; its atomic weight is 96.0; specific gravity 8.6-9.01, and specific heat 0.066. Molybdenum is a metallic element whose compounds are quite widely diffused, but its ores are very rarely found in considerable quantity. It has never been discovered in nature, but invariably alloyed with some other compound, of which it generally forms but a limited percentage. It is a white metal, hard, and somewhat malleable. The ore of molybdenum, on which the world depends for its main supply of the metal, is molybdenite, a sulphide, MoS_2, which occurs in hexagonal plates or masses, thin, foliated similar to graphite, and much resembling that mineral. This ore has a grey color and streak, olive-colored on white paper; it can be differentiated from graphite by its high specific gravity. Molybdenite occurs in a great variety of rocks in different parts of the world, including practically all the main groups, but its occurrence with granite and the more acid rocks, of which that is the type, is by far the most usual and typical. When molybdenum ores occur in veins, in quantity, they are usually in the form of oxides, as well as of sulphides.

Another mineral which has been found commercially suitable as a source of molybdenum is wulfenite, a lead molybdate. This ore, to be useful as a source for molybdenum, must not carry as impurities large quantities of copper, arsenic, vanadium or iron. The ease or difficulty of concentration has much to do with the feasibility of profitably mining and developing molybdenite deposits. Unless the minerals occur in tolerably large lumps, so that they can be hand-picked, it has been found somewhat difficult to discover a satisfactory method of separating the ore from the gangue material. Both the oil and the static electric methods have been used with varying success. Only rarely does the mineral occur so coarsely divided that it may be hand-picked; the ores are prepared for the market in two forms—powdered, and as ferro-alloy. The powdered form is obtained by heating some form of oxide with a reducing agent, such as carbon in the form of charcoal. The first stage produces the dioxide, which is not readily volatile. Prolonged heat and high-temperature result in the production of the metal. Ferro-molybdenum, with varying molybdenum content, is made by the use of the electric-resistance furnace, either direct from the sulphide, or from the roasted high-grade sulphide. By this process the impurities can be slagged off; in the case of the powdered metal the impurities are subject to extraction by means of a solvent, otherwise they remain with the metal.

Molybdenum alloys are made in part at the Niagara Falls by means of the electric furnace, and when they are made elsewhere metallic aluminum is largely used as a reducing agent, which is also a Niagara power product. These alloys form the chief constituent of a group of products which are absolutely necessary in the manufacture of high-speed tool steel, magnet steel and a variety of special steels. Alloys can be formed of the two elements molybdenum and tungsten by compressing a mixed powder into briquettes, and then heating them with an electric current in an atmosphere of hydrogen. Alloys can be produced varying in composition from 100 per cent molybdenum to 100 per cent tungsten. Thermal and microscopical analyses show that molybdenum and tungsten are completely isomorphous. All alloys of this series are malleable and ductile under proper conditions. Alloys of molybdenum and tungsten have been suggested as a substitute for platinum and its alloys the prices of which are abnormally high. It has been ascertained that, except in two respects, molybdenum meets the requirements of a practical substitute. These two defects are its relative ease of oxidation and the difficulty with which it can be soldered; but both appear to have been overcome by coating with a precious metal or alloy.

Several localities for the supply of molybdenum ores may be briefly referred to. Ores have recently been found in New Zealand, at Takata, and samples assayed are stated to have contained 50 per cent of molybdenum oxide. Ores occur in New South Wales and Queensland; works for treating them have been established in Sydney.

Several deposits of the ores occur in Eastern Ontario; these have been opened out and are being worked. There are dressing plants at Renfrew and Ottawa. Ferro-molybdenum is being made at Orillia and Belleville. The so-called "sierra" district of Peru are highly mineralized, and contain molybdenum ores, as well as many other minerals.

For several years important molybdenite mines near Thelomarken, in Norway, have been worked in a somewhat primitive manner, but during 1916 a more modern system has been introduced. The value of the output has increased fourfold during the last two years. During 1912-13 it was only worth 4s. per kilogram (2.2 lb.), but the average price last year was about 1*l.* per kilogram. A large number of borings have disclosed molybdenum ores to a very considerable depth. The Dalen deposits are stated to be most important and of exceptional depth, the quality is also satisfactory; at the Kvina molybdenum mines the rock contains an average of 10 per cent of molybdenum; while at the Dalen mines the percentage is probably even a higher one. Crushing machinery capable of dealing with 100 tons every 24 hours has been installed, and it is intended that the washing plant should be kept continously at work, day and night. The product, it is estimated, will contain about 97 per cent of molybdenum. It is proposed to establish a works for the production of pure molybdenum by an improved process.

Up to the close of 1911 the demand for molybdenum remained stationary and very limited in the United States; with the exception of some slightly increased use of the metal in Europe the outlook did not look at all encouraging. The production in the United States was very small, hardly worthy of notice—not due to any scarcity of the substance, but to small demand. More recently a larger supply was required, which resulted in an active search for molybdenum ores in the United States. During the spring of 1915 molybdenite concentrates were produced from a mine near Empire, Colorado. This is the first American mine to be extensively operated for molybdenite.

There are several known localities in the United States and Mexico where molybdenum ores could be mined profitably; they occur in more or less widely separated localities north of the international boundary of the United States and Mexico, in the Santa Rita and Patagonia Mountains, not far from the Southern Pacific Railway; in the Pinna and Santa Cruz counties, Arizona and New Mexico, also to a very limited extent miles southeast of the town of Tucson. Wulfenite has been found in a number of places in Utah, Nevada, Arizona and New exico, also to a very limited extent in California and some other States.

New and sensitive tests for molybdenum are now available; the older tests yielded a characteristic blue color, which appeared as a fugitive tint in the first stage of the reduction of molybdic acid by nascent hydrogen. It is now possible by means of an improved test to obtain a permanent blue color; hydrazine, N_2H_4, forms a good reagent for developing it. A solution containing a trace of alkali molybdate when acid solution of MoO_3 is treated with potassium iodide hydrazine sulphate and boiled, rapidly turns deep blue and retains the color on boiling. When a slightly acid solution of MoO_3 istreated with potassium iodine (in some excess) and boiled for some time, iodine is slowly liberated and the solution turns blue. A well-known and tolerably sensitive test for molybdenum is that in which the acid solution is treated with sulphocyanide and a small scrap of zinc added—a crimson color is then obtained in a few seconds. Should iron also be present the solution becomes blood red when the sulpho-cyanide is added, but when the zinc is placed in the solution it becomes colorless, through reduction to the ferrous condition, but after a few seconds becomes crimson, should Mo be present.

To test molybdenum minerals a pulverised specimen is moistened with concentrated sulphuric acid in a porcelain crucible and evaporated almost to dryness. Upon cooling, should molybdenum be present, the crucible will have a beautiful dark blue coating, which is presumed to be a mixture of oxides. This test is readily and easily performed, it is characteristic, and no element or mineral generally associated with molybdenum compounds is known to interfere with this test. The mineral with which molybdenite is most likely to be confused is graphite, which occurs in some localities in flakes, almost, if not quite, as flexible as those of molybdenite. The latter also occurs in a form which gives no suggestion to the eye of a flaky structure. There is, moreover, generally a noticeable difference in color, as the graphite is an absolute black, while the molybdenite has a greyish metallic apearance; but even these characteristics are not absolutely reliable, as impure molybdenites are known which are glassy black, with no suggestion of flakiness, and which, moreover, give a black streak, though the usual streak, as stated above, of molybdenite is olive-tinted on white paper. In addition to the test mentioned above, molybdenite may be differentiated from graphite by treatment with nitric acid. Molybdenite is attacked by the acid, with a resulting white or grey powder (molybdic oxide), while graphite is not affected at all. Molybdenum is not affected by air at the ordinary temperature, but it slowly oxidizes when heated to redness. From a concentrated solution of any molybdate nitric or hydrochloric acid causes a white precipitate to be formed.

There are many uses to which molybdenum and its various compounds have been put, as ammonium molybdate to determine phosphorus in iron; as a fireproofing material; as a germicide; as a disinfectant; as sodium molybdate to color pottery and porcelain blue; to dye silks and woollens; as molybdenum tannate to color leather; and as molybdenum "indigo," Mo_3O_5, it is a useful but expensive pigment for india-rubber, which, it is stated, is not injured by its use. Molybdite, known as molybdic ochre, is a straw-color to white material containing from 50 per cent to 60.7 per cent of molybdenum, and is considered to be a hydrated iron molybdate. There are a dozen or more known salts of molybdenum. most of them of only scientific value.

Molybdenum is one of the metals which at present commands a tolerably high price, but it is possible that by improvements in metallurgical processes it may in the not distant future be produced at a considerably lower rate. During 1910 the price ranged from 10d. to 15d. per pound for material carrying 92 per cent of molybdenum sulphide, equal to from 93*l.* to 140*l.* per ton. During 1915 the price was about 208*l.* per ton, and at the end of 1915 and the commencement of 1916 it was 312*l.* for 95 per cent product. The Canadian output of concentrates during 1915 approximated to 20,000 lb., valued at 4s. 2d. per lb., equal to 466*l.* per ton.

The terms "unit" or "content" are frequently used in quoting the price of molybdenum ores; the former refers to the price per net ton of ore guaranteed to contain a given percentage, possibly with bonus or penalty per unit for anything over or under the given percentage. The word "unit" is used in the same sense as per cent. The "content" system is a somewhat simpler mode of quoting, thus: 3s. per pound for MoS_2 contained in concentrates of 90 per cent molybdenum sulphide. An example will make the system clear. If 10 net tons of 93 per cent concentrates are purchased, then that percentage of 22,400 lb. would be 20.832 lb., which, at 3s. per pound, would amount to 3,134*l.* 16s.

With such limited natural supplies of molybdenum ores it is important to prevent loss, or to reduce it to a minimum. By the flotation process waste has been prevented, as it has been successfully applied to molybdenite ores on a large scale without the use of either acid or oil. The antagonism of the surface of the mineral itself to wetting action is sufficiently pronounced to enable it to be floated off under the conditions in practice. Even after having been crushed wet and passed through an ordinary wet concentration mill it may still be floated by bringing it in a suitable manner upon a water surface. Thus at one mine the tailings from a wolfram-bismuth concentrating mill, all passing a 20-mesh and containing only 2 per cent to 4 per cent of molybdenite, are treated by passing them over suitable flotation boxes without the aid of acid or oil. The flotation appliances consist of a series of cone-shaped boxes, with the usual overflow, the ore being fed on to the water surface by means of an inclined plane; the molybdenite, in the form of a thin scum, passes over the overflow lip, while the tailings are discharged at the bottom of the boxes. The necessity for a rapid forward movement of the flotation surface involves the use of a somewhat large overflow of water, which is contaminated with the gangue of the ore. Instead of the molybdenite overflowing with the water, it may be intercepted by a belt, on to which it floats, and it is then carried across the overflow lip, while the water passing over the lip is free of molybdenite. The clean molybdenite is washed off the take-off belt into a settling trough, while the gangue passes out at the bottom of the flotation boxes. At an American mine molybdenite and pyrite are being successfully separated by the flotation process. The ore, carrying about 25 per cent of iron pyrite, has been separated by the use of a weak hot solution of sodium bichromate. Molybdenite is so much more readily floated than pyrite, that a solution of sodium bichromate is almost unnecessary in many cases.

*Engineering.

The Making of a 6-inch Reflecting Telescope—III.

Instructions for the Amateur Instrument Builder

By C. J. Larson, M.D.

Concluded from Scientific American Supplement, No. 2180, Page 238, October 13, 1917

IX. The mounting

A proper mounting is a necessity for the proper performance of any telescope large or small; even a little spyglass will yield results when well mounted that one would never get by holding or resting it on some support. And then mountings may be constructed of the commonest materials, for instance the polar and declinition axes and bearings may be made of gas pipe fittings, and after applying a coat of paint a very presentable appearance results.

Most telescopes are mounted "equatorially," in fact, all large ones are. This mounting is the only one that permits keeping an object in the field for any time. The earth turns on its axis, and so makes it appear that the heavenly bodies rise in the east and set in the west.

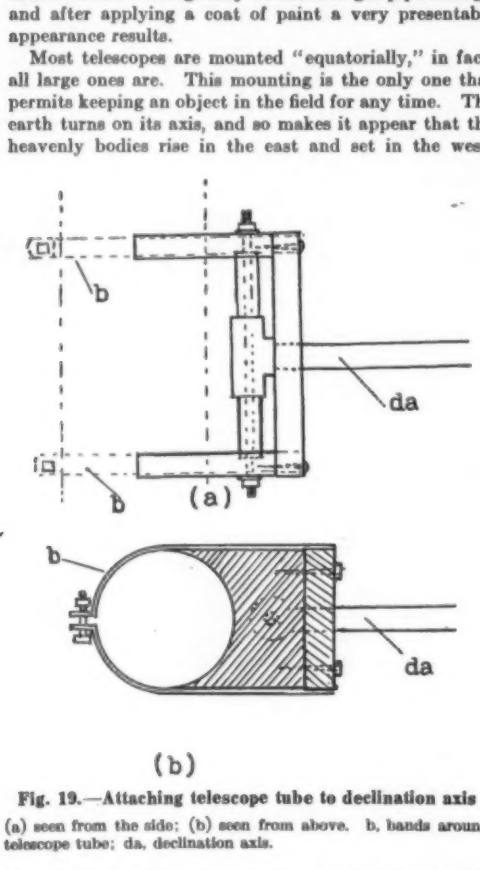


Fig. 19.—Attaching telescope tube to declination axis

(a) seen from the side; (b) seen from above. b, bands around telescope tube; da, declination axis.

Now if the so-called polar axis of a telescope mounting is in line with the axis on which the earth turns, all that is needed to keep the telescope pointed at an object in the sky is to turn its mounting on this polar axis and in the direction opposite to that of the earth's turning.

The two axes of an equatorial mounting permit pointing the telescope at any object in the heavens. The polar axis is parallel to the axis of the earth itself, and the declinition axis is at right angles to the polar axis. In the form commonly used the polar axis carries a T-shaped connection at its upper and in this T are the bearings for the declinition axis. In home made mountings gas pipe fittings offer a convenient assembly for this purpose.

Mountings are portable or fixed. Refractors of six inches and less are often mounted on portable tripods; and while reflectors can usually be mounted in a similar manner, the arrangement here described is more rigid and easier to make than the ordinary tripod. The material needed is a piece of timber from four to six inches square and about four feet long, and two pieces of 2 x 4. Fig. 23 explains the construction. The heavy piece is placed at an angle equal to the latitude of the place where it is to be used. One inch or 1¼ inch gas pipe makes a good polar axis. A T is attached to the upper end. The horizontal part of the T, with a short piece of pipe screwed into each end of it, forms a support and bearing for the declinition axis. The polar axis turns in bearing boxes mounted on the heavy timber, and if regular bearing boxes cannot be obtained good substitutes may be made of wood, especially if the bearing surfaces are lined with sheet brass.

The declinition axis turns then in the horizontal part of the T at the upper end of the polar axis, and the declinition axis carries the telescope tube at one end and the counter weight at the other end. Fig. 19 indicates a very practical way of attaching the telescope tube to the

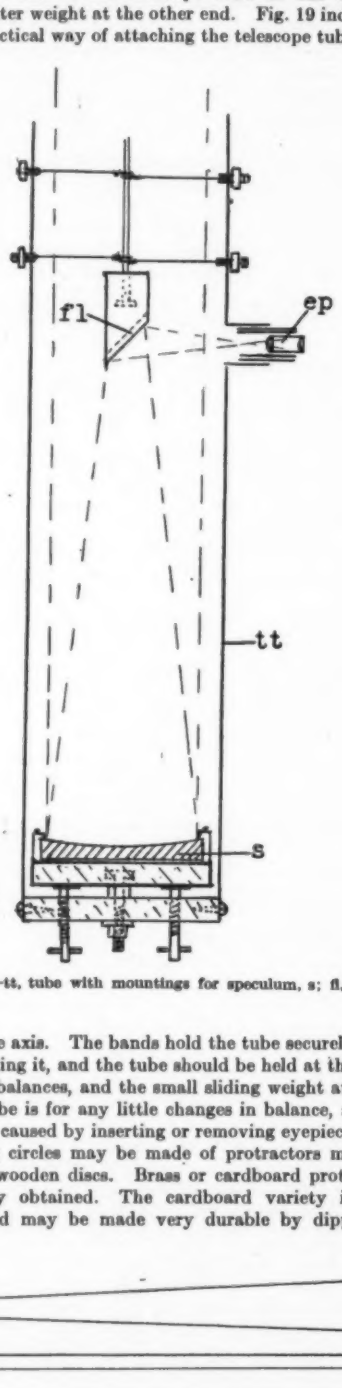


Fig. 22.—tt, tube with mountings for speculum, s; fl, flat; ep, eyepiece.

end of the axis. The bands hold the tube securely without buckling it, and the tube should be held at the point where it balances, and the small sliding weight attached to the tube is for any little changes in balance, such as might be caused by inserting or removing eyepieces.

Setting circles may be made of protractors mounted on light wooden discs. Brass or cardboard protractors are easily obtained. The cardboard variety is very cheap and may be made very durable by dipping in melted paraffine. The protractors may be attached to the wood disc by means of small screws or light tacks. A block carrying a mark for reading the circle is placed close up to the edge of the circle. The circle may be just tight enough on the shaft to permit turning it in setting, and still remain where set; or a hub with a set screw may be provided. The circles and their use will be discussed later.

Fig. 19 shows a good way of attaching the telescope tube to the end of the declinition axis. The counter weight at the other end of the axis may be any convenient object that may be mounted so as to permit sliding to the point where it balances the tube. The small sliding counterpoise on the rod attached to the tube is to keep that part in equilibrium, and may be adjusted to balance different weight eyepieces. All

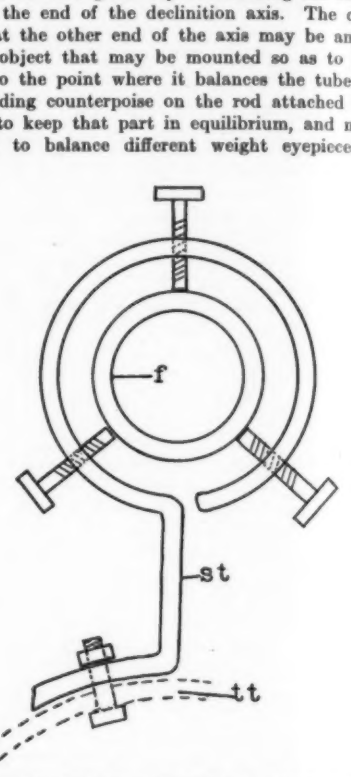


Fig. 20.—Standard for mounting and adjusting finder

f, finder; st, standard; tt, telescope tube.

parts should be perfectly balanced. The set screw at the top of the T at the upper end of the polar axis provides a means of clamping the declination axis. A clamping arrangement for the polar axis my be easily provided. A piece of wood shaped like one of the halves of a bearing box and with a large thumbscrew replacing one of the nuts, serves well.

The heavy piece of mounting should be set at an angle equal to the latitude of the place where it is set up; and this is around 45 degrees in the norther parts of the United States. The polar axis should be lined up with the pole star. That star is 1¼ degrees from the pole, and when the big dipper is beneath the pole star, that star is almost directly above the true pole.

To set the circles proceed as follows: Locate the pole star, and also the celestial equator. In winter the uppermost of the three stars in the "belt" of Orion is almost on the celestial equator. In early summer draw an imaginary line from Arcturus to Spica. The equator crosses this line at a point about one-third of its distance from the lower star. A star atlas or even the maps in the Sunday papers will be useful. Now point the telescope so the pole star is in the center of the field. Set the circle at 90 degrees declinition. Turn it to the equator. It should read 0 degrees. (A correction of 1¼ degree should be made in setting by the pole star.) This completes the setting declinition. Readings north of the equator

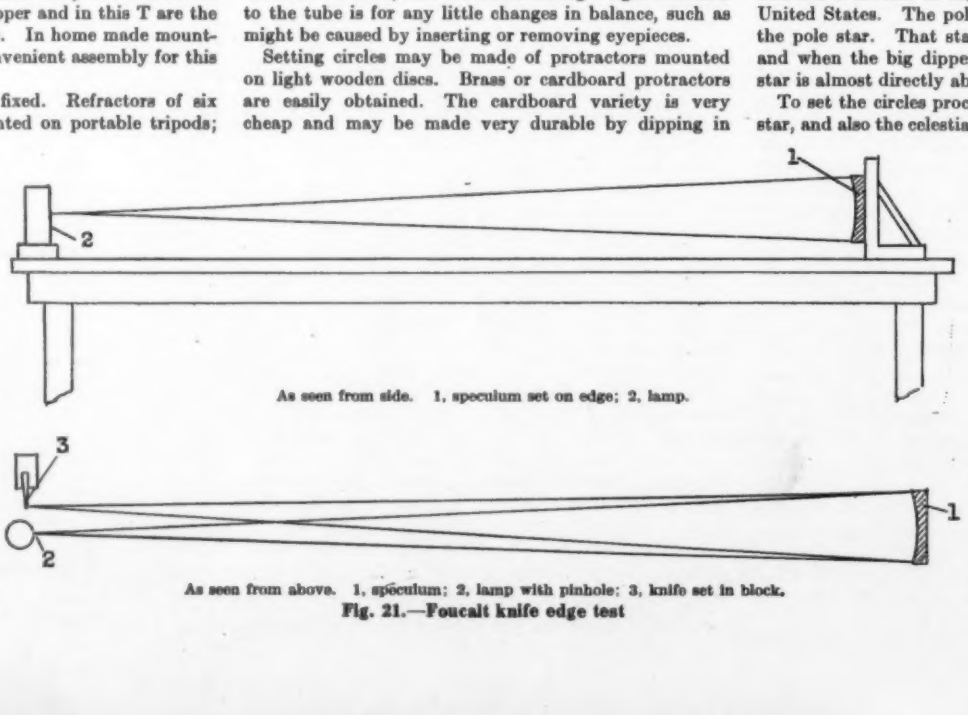


Fig. 21.—Foucalt knife edge test

are + (positive), and those are—(negative). Declinition is abbreviated "decl"; some times the small Greek letter δ (delta) is used. The circle is divided into 360 degrees, but the readings being each way from 0 degrees, 180 degrees is the greatest range. Degrees are divided into minutes and minutes into seconds. A star is thus designated as being "d 23° 14′ 13″.

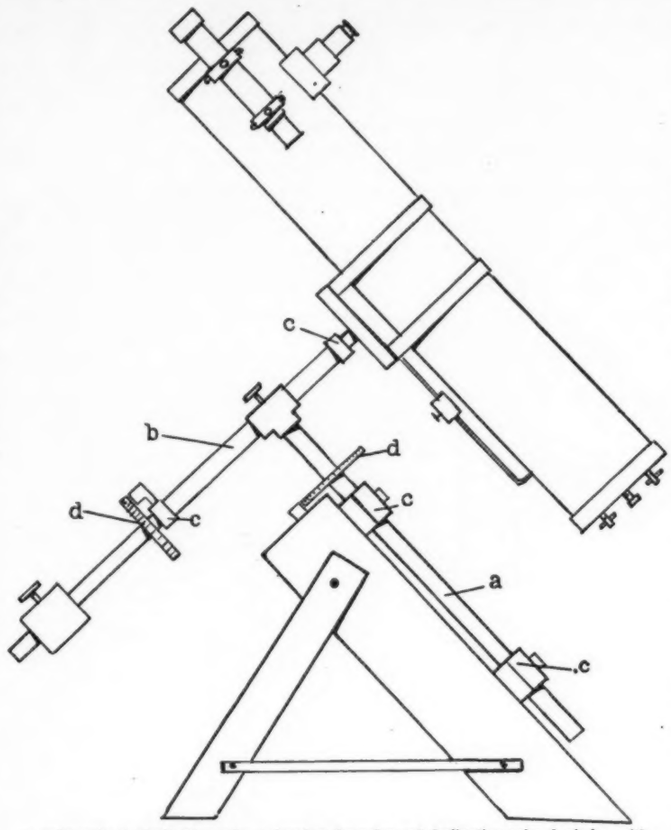
The other circle is styled the "hour" circle, because right ascenscion is given in hours, minutes and seconds, instead of degrees. A. R., and sometimes the small Greek letter α (alpha) are the usual abbreviations. The circle is divided into 24 parts, and our protractor circle, which has 360 degree-divisions, is thus marked off at every fifteenth degree. Hours are counted from 0 clear around the 24 divisions to 0 again. Turn the telescope on the polar axis until the tube is horizontal and set at 0. (Note that each hour being 15 degrees of the circle, each degree will represent four minutes.) A star's position would be designated, "R.A. 8 h 18′ 32″. Right ascension is reckoned from the vernal equinox, and so a sidereal clock is needed to enable any observer to get an exact position. But the amateur may calculate by means of a star map the distance from some bright, easily found star to the object sought and then use his circles to measure off the difference on the sky.

For a "finder" a spyglass of from one to two inches may be used. In a preceding paragraph the beginner was advised to get a low-priced glass of that type, for the purpose of familiarizing himself with the different parts of a refractor. learning to use a telescope, and then finally using it for a finder with the reflector. A celestial eyepiece must be used, and one of a low power. The finder is attached to the telescope tube by means of two standards. These are made of strap iron or brass, shaped as indicated in Fig. 20. Three holes are drilled and tapped to take small bolts. The base of the standard is bolted to the big tube. Bring any object into the center of the telescope field. Clamp the telescope. Then by means of the adjusting screws of the standards, line up the finder so this same object is in the center of the field of the finder. It may be a little confusing to locate objects in a Newtonian reflector, particularly before one is accustomed to its use. A finder is almost a necessity on any telescope.

It is inconvenient to cart such a telescope in and out doors. Unless one has a regular observatory for housing the instrument, it is better to leave it out in the open. With caps fitted over the mirrors, and one over the open end of the tube, and with a canvas cover of suitable size and shape placed over it, no damage will result from the exposure to cold. In fact it is more harmful to take cold mirrors into warm rooms, on account of the condensation of moisture on the cold glass. If such a glass must be taken into a warm room, warmed, dry absorbent cotton should be lightly laid over it, or held near it to absorb the moisture until the glass has attained the same temperature as the air of the room. The film should never be touched with the fingers, nor with any other object, and dust should be removed only by means of a camel's hair brush or a lightly held fluff of absorbent cotton.

X. THE FOUCALT KNIFE EDGE TEST

One hears of the Foucalt "knife edge test," but some writers mention it only to advise the amateur telescope maker that it is beyond him. This test is not any more beyond him than the figuring of the mirror or the silvering. While we do not intend to take space to go into the subject in detail, we shall discuss it sufficiently to permit the reader to get some idea of this beautifully exact and delicate testing procedure, and then advise that he read and study Ritchey's chapter on the subject in that author's excellent article on reflecting telescopes. A reprint of that paper will be found in No. 1516 of the SCIENTIFIC AMERICAN SUPPLEMENT, and I would advise reading the entire paper which runs through six numbers of the SUPPLEMENT.



a, polar axis; b, declination axis; c, bearing for polar and declination axis; d, circles, with blocks set near edge (declination axis tipped up to better show construction).

Fig. 23.—Telescope with complete mounting

An oil lamp or an acetylene bicycle lamp, over which one can place a tin cover, a block of wood in which is mounted an ordinary safety razor blade of the wafer type, is all that is needed for the test. The mirror can be tested—in fact should be—before silvering. The glass is usually smooth enough after fine grinding, before polishing even.

Mirrors not over six inches may usually be finished and used with good results without having applied the knife test, and if the amateur does not wish to tackle the job at this stage, he may carry it out later, say when the mirror needs to be resilvered. And in the mean time he can study up the subject and experiment a little.

Fig. 21 shows the arrangement for the test. The mirror is set up on edge and at a distance twice its focal length, which is its center of curvature. With our six-inch glass of five-foot focus that would be 10 feet. (From lamp and block.) The smallest possible pinhole is made in the tin cover of the lamp. The smaller the hole the better. It should not be over $\frac{1}{64}$ inch, though $\frac{1}{32}$ may do. The pinhole should be in front of the brightest part of the flame. The mirror should be tilted enough to throw back the light from the pinhole an inch or so to the left side of the lamp, and here must be the block with the knife blade. The block must be so it may be slid sideways. The eye must be placed right back of the block. Knife edge and pinhole must be the same distance from mirror. Now if the figure of the glass is correct, it will show up thus: when light from the pinhole is thrown on the mirror and reflected back to the eye back of the knife, the disk is all illuminated, and when the knife is slid crossways from the left to right (toward lamp) the disk darkens uniformly, as if the light were weaker all over, while if not correct in figure, lighter and darker rings, hills and hollows, and other configurations appear, Getting the eye and knife at the proper distance is important and very plainly described in the Ritchey paper.

So here is a test that requires a lamp, a tin cover for same, a block of wood, and a razor wafer blade (or any sharp straight edge) and when the tests is once learned it is surprisingly easy. The principle involved is this: the pinhole is nearly the theoretical "point" of light, and if all parts of the mirror are correct, the rays from all parts would be reflected right back to the pinhole, but when the mirror is tilted to the side very slightly, the rays are returned to a point just at the side of the lamp. Now the eye is placed so the retina of the eye will receive the very tip of this cone of light, and as these rays come from all zones of the speculum, the speculum appears evenly illuminated. Now because all of these rays strike the retina at the same place—at a point—the eye cannot tell what zone or part of the mirror the light comes from. It can only tell whether much or little light strikes the retina at the point. Now when the knife edge cuts off some of the rays, it cuts off some light and the disk uniformly darkens all over. But if different parts or zones of the mirror have different foci, and the cone of light rays consequently does not come to a point on the retina, these parts or zones have their foci either in front of the retina or behind the retina, and so they will appear as raised or as depressed rings or zones, and when the knife edge cuts off rays from such parts it does not have the effect of uniformly darkening the whole disk, but produces the appearances stated. Fig. 21 will help to make the principle clear as well as aid in carrying it out. Many have gotten wrong conceptions of the test at the outset, and it is surprising how little literature there is on the subject in standard works. A very common misconception is that the knife edge must be moved across the pinhole, instead of across the line of the rays from the mirror to the operaor's eye, which is at the side of the lamp.

A plain mirror, such as the diagonal flat, but more particularly the large plane reflectors used in changing the direction of light rays in certain optical arrangements, may be tested in a similar way; but we shall take time here only to say that such may be done by placing the plane so as to reflect light from a tested concave mirror, and if the plane is true the light from the concave mirror is brought to a point just as truly as if the plane reflector had not been inserted in the path of the rays from the concave glass. A little experience is all that is necessary.

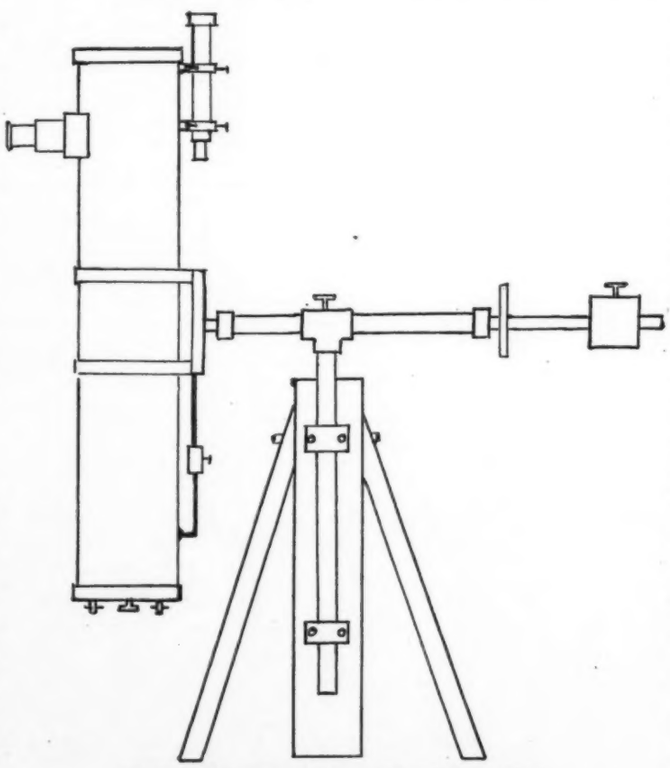


Fig. 24.—Declination axis horizontal and tube vertical

The mirror must be at the correct distance from the knife edge and pinhole. This distance is twice the focal length. To determine the proper point proceed as follows: place as nearly correct as you can, then slide knife across the cone of light. If a shadow seems to cross from left to right you are inside the distance and must place mirror further away. If when you slide the knife across from left to right as before there is a shadow that passes across in the opposite direction—from right to left—then you are outside the correct point. Do not confuse this shadow with those produced by an incorrect figure of the mirror. The proper distance must be found first, by observing shadows passing across the field. Then when this distance has been correctly determined you will observe the other changes in illumination of the disc. If correct in figure the disc will darken uniformly all over when the knife edge is slid across the path of the light. If rings or zones of incorrect focus exist, rings that appear either elevated or depressed will show up when the disc is viewed. To correct the figure, polishers are made of shapes such as to wear away high zones. If deep zones exist polishers are used to wear away the remainder of the surface while the depressed zone is not worn down. To determine the defects and make the necessary corrections is not very difficult but requires a little time and patience. We shall not go into the subject further here, but again I advise to study up the matter as given in the Ritchey paper.

Thus it has been my endeavor to detail in as simple and direct way as possible each step in the making of this telescope. As stated at the outset, the only operation that will be a new experience to the average person is the making of the speculum, and the figuring and silvering of the mirror will be just as new an experience to the skilled mechanic as to the amateur workman. They are at par in this matter. But aside from this, the reader is not in any instance directed to perform any operation calling for unusual material or any special tool equipment. The only tool I should advise the amateur workman to get is a hack saw. It will cut wood, steel, brass, fiber—in fact most anything—and should cost not over 50 cents. A vise is also an extremely useful article, and one of small size may be obtained for a dollar or two.

The Etiology of Some Obscure War Diseases

THE association between war and pestilence is proverbial, and it is one of the triumphs of medicine that in this greatest of wars we have been spared grave epidemics. A comparison between the mortality from wounds and diseases in this war and in the South African War gives a measure of the unchallenged advance of preventive medicine. But fresh forms of disease have called for increasing vigilance and research. Some of these have been widespread, yet of low mortality—for instance, epidemic nephritis, almost unknown in warfare, except in the American Civil War, has been prevalent in France, though absent from the British training camps. The immediate death-rate of this nephritis has been small, but it is too early yet to gage the ultimate damage which has been accomplished by the disease. Probably it is due to an infection, but, unfortunately, the organism is still unknown, and while this is so no effective means of prevention can be adopted. In spite of this there is good ground for believing that, as in the later phases of the American Civil War, epidemic nephritis is gradually diminishing. In every war indeterminate fevers have abounded. In South Africa we heard much of "simple continued fever," which in the majority of cases was probably merely a mild form of typhoid fever, for in uninoculated patients the Widal reaction was generally found to be positive. The absence of this type of simple continued fever now is correlated with the control that has been acquired over typhoid fever and its congeners. But from the medley of irregular pyrexias, myalgias, rheumatisms, and "influenza" the features of a definite disease have been gradually recognized and labelled trench fever. The headache, drowsiness, and pains in the shins were associated with a relapsing fever, the course of which suggested the activity of a hæmatozoon. The work of Captain J. W. McNee and Lieutenant A. Renshaw,[1] showed that there was something in the red corpuscle of infected persons which was capable of conveying the disease to others, but no actual organism was found, although the punctate basophilia found was the subject of remark. An interesting and important communication from Captain Lyn Dimond points to the presence of a hæmogregarine as the cause of this form of relapsing fever. The blood from cases of trench fever was hæmolyzed by the addition of a saponin, after which the parasite could be found moving in the centrifugalized deposit. The hæmogregarine was also discovered in the liver, and less constantly in the spleen and lung, rarely in the lympathic glands and not in the cerebro-spinal fluid. Spleen puncture was found to be the quickest way to establish the diagnosis. The broad facts of the life-cycle of the parasite appear to be established. A day or two before the onset of pyrexia macromerozoites are found free in the plasma of venous blood, and micromerozoites, which are more commonly encysted. These merozoites increase in number up to the height of the fever when they disappear, and the day after the pyrexia only the parthenogenetic macrogamatocyte can be found which undergoes division into 20 macromerozoites just before the rise of temperature, when sporulation occurs. This is the asexual generation, but the main features of sexual generation have also been observed.

If further investigation confirms the suggestion that the protozoon of trench fever is a hæmogregarine, it becomes highly probable that either the *Pediculus corporis* or a louse allied to the one parasitic on the Indian field rat, is the carrier of the protozoon. The association of this fever with trench life, where large numbers of rats come into close association with the troops, favors this conclusion. Trench fever is not dangerous to life, but it is a cause of considerable suffering and much incapacity. It is probably one of the various infections and intoxications which lead to disordered action of the heart, and thus is responsible for much prolonged disablement. Its effective treatment is accordingly a matter of much importance, and so far nothing has been found to cut short its course. A case is recorded by Dr. R. V. Solly in which the character of the fever raised a suspicion of trench fever, was cut short by a single dose of galyl, although other observers have had negative results with the same drug. Special interest therefore attaches to Captain Dimond's observation that trypaflavine slows the movements of the parasite *in vitro*, and has given good clinical results when administered intravenously. The growth of our knwoledge of trench fever is a typical example of the steps by which such problems are solved. Similar steps are well illustrated in our knowledge of certain nervous diseases. For instance, "locomotor ataxy" describes a symptom, "tabes dorsalis" correlates this with an anatomical lesion. But a great advance was made when this lesion was traced to a parenchymatous degeneration of the lower sensory neuron produced by syphilis. In trench fever the stages have been the recognition of certain scattered symptoms as due to some common cause—then the recognition of this cause as a specific infection; and, finally, the identification of the responsible parasite. It emphasizes, again, the importance of studying the etiology of disease and the way in which the center of interest is shifting from the wards to the laboratory.

This is further brought out by a paper in the current issue of *The Lancet* on a form of purulent bronchitis by Captain A. Abrahams and others. We previously published a communication on this subject from one of our base hospitals in France, so that the disease is evidently widespread. Unfortunately the mortality is high—of the cases reported from France the death-rate when the epidemic was most savage was 45 per cent, while that of the Aldershot cases was 25 per cent. The chief clinical features would appear to be the characteristic expectoration of yellowish-green masses of pus which may be the first symptom, the rapid respirations, the extreme tachycardia, the marked cyanosis, and an ante-mortem drop of temperature, an evidence of the extreme toxæmia, The morbid anatomy of the lung shows the bronchioles to be completely obstructed with pus, catarrhal cells, and débris, with small round-cell infiltration immediately surrounding them. The alveoli are usually very little affected and though there may be a secondary bronchopneumonia this is not characteristic of the disease. The other lesions found are evidences of toxæmia and of failure of the right side of the heart. Treatment has not been satisfactory. The early recognition of the case by the character of the sputum is of primary importance, for if the patient is allowed to struggle against the disease at the beginning the outlook is made much worse, If cyanosis supervenes the prognosis is grave. Both sets of observers are agreed as to the etiology of the disease—it is primarily influenzal—Pfeiffer's bacillus seems to be constantly present. But there is usually a mixed infection, pneumococci being the organism most frequently associated with the influenza bacillus. It may be asked why, with two such well-recognized organisms, should we meet with a new and dangerous form of bronchitis? The suggestion is that it is an example of exaltation of virulence by symbiosis. The pneumococci found in the early stages are of low virulence, but the two organisms stimulate the virulence of each other, and the fatal termination is by a pneumococcal septicæmia. So that the symptom of an "acute suffocative catarrh" is traced to an obstruction of the bronchioles by purulent exudate with peribronchial infiltration as its anatomical basis, and this in its turn is traced to a double infection, apparently with true symbiosis. Certainly investigations of the etiological factor in these two diseases, trench fever and purulent bronchitis, have yielded results full of interest and promise.—*The Lancet.*

[1] *Brit. Med. Jour. 1916, i., 225.*

Washing Dishes

WASHING dishes has always been the despair of the housewife. The quickest and easiest way always has preference. We can't say that we blame her. Many a man would forego eating from dishes if he had to clean them, especially after a hearty meal when the thought of labor is hateful.

Washing preparations, with which the market is crowded, may have their uses, but plenty of simple boiling water and good soap will accomplish a complete cleansing of dishes and cooking utensils; whereas many of the so-called labor-saving washing devices and their like are rarely of any practical value or utility. A thorough rinsing with boiling water completes the process and insures cleanliness. Boiling water should be the chief accessory in every kitchen equipment at all times.

It is plainly evident that the utmost care and attention should be given to the proper handling and preparation of our foods. Experience has clearly shown that the slightest lapse in the kitchen may lead to the direst consequences. For this reason medical men will do well to neglect no opportunity of preaching the importance of kitchen cleanliness and the proper care of foods.—*American Medicine.*

Shelling the Enemies in the Air

ALTHOUGH the persistent raids on London by German air-craft have had but little practical result so far, beyond the moral affects on the inhabitants, they have demonstrated the futility of the anti-aircraft gun as an efficient means of defense, for, although they have apparently proved too much for the huge Zeppelins, they are of little avail against the lilliputian aeroplane. While the huge Zeppelin offered a possible target, in spite of her speed, the diminutive airplane offers such a small objective, at the height at which it works that a hit can only be made by accident, and considerable fleets of these assailants have successfully made their way through, or over, the fierce barrage fire that has been organized against them. In using these guns absolute direction of fire can hardly be of as great importance as the height at which the shells thrown are set to explode, for the small flyer is much more liable to be damaged by the multitude of places scattered by the explosion of a shell, or the shower of bullets from shrapnel, than by a direct hit, for a shot through a wing is of small importance, and to be effective either the operator or a vital point of the mechanism must be struck; and these are but very small points at elevations of say 10,000 feet. Still it is well to be provided with this new form of weapon, and our newer battleships all carry several of these guns, as shown in the first page illustration.

The anti-aircraft guns used by the different nations are of various sizes, one of the largest reported being of German make, which has a bore of a little over 4 inches. This has a range of about 13,000 feet, vertical; but it is claimed that some of the German guns of lesser caliber can reach to 19,000 feet, and from 15 to 25 shots a minute can be fired.

Soap Substitutes and Washing Powders

SOAP substitutes now on the market in Germany consist of mixtures of clay, chalk, alkali carbonates, sodium sulphate, sodium silicate, and gelatin or other binding material; a small quantity of boric acid or salicylic acid is added as a preservative. Substances containing saponin are sometimes added to the mixture. A material for washing fabrics is prepared from the tryptic enzyme of the pancreas, but this preparation cannot be used at temperatures above 40° C. A solid soap is made by heating together 10 kilos. of resin, 1.5 kilos. of sodium carbonate, and 3.5 liters of water and then adding 70 kilos. of clay, 5 kilos. of sodium carbonate, and 10 liters of water. The washing powders usually consist of mixtures of sodium or potassium carbonate, ammonium chloride, clay, and saponin, and sometimes perborates; sodium peroxide and carbon tetrachloride are also used in these mixtures. One soap powder which is sold contains 17 per cent of soap. 3 per cent of resin soap, and 80 per cent of fillers, the latter including 50 per cent of sodium carbonate and a quantity of sodium silicate. The use of an extract of linseed has been proposed as binding material for soap substitutes.—Note in the *Jour. Soc. Chem. Ind.* on an article by M. BOTTLER in *Chem. Zeit.*

The Brown Coal Distillation Industry of Germany*—I

Methods, Apparatus and Products Resulting

By D. R. Steuart, F.I.C., F.R.S.E.

Brown coal is a substance intermediate in its nature between peat and ordinary coal. Formed in comparatively recent geological times, Tertiary or Cretaceous, it has not yet developed into a true coal. Peat contains 80 or 90% of water from which it parts with great reluctance; it cannot be separated by pressure. Brown coal or lignite has 20% to 60% of moisture, common coal 2% or 3%.

There is little brown coal in Britain. At Bovey Tracey in Devonshire it has been worked for 200 years but is of only local importance. There are vast fields of it in the United States of America; great fields of unknown extent in Alberta, Saskatchewan, and Manitoba, Canada; and some 1,700 square miles of it in Victoria, Australia. Brown coal generally has no great covering on it, lies in beds of great thickness, and can often be worked opencast. The amount of water in it is a great drawback, and also its want of coherence when air-dried. In Manitoba, Saskatchewan, and Alberta it cannot be used for locomotive fuel on the railways on account of the dangerous sparks it throws out.

Brown coal is widely distributed through middle and north Germany and in Austria. Near Cologne it is 260 to 400 feet thick. Improved methods of mining and of preparing the products have given great importance to the industry in Germany and these methods are worthy of consideration in other parts of the world.

In the German Empire in 1905 the total coal output was 121 million tons and 30% of that was brown coal. The total output of coal in 1910 was 222 million tons. The coal production in the British Empire in 1910 was 312 million tons.

In Germany for the last half century brown coal has been subjected to low temperature distillation, and it may be of interest to give some description of the process for comparison with our Scottish shale oil industry. The products of the distillation are somewhat similar: permanent gas, spirit, lamp oil, gas oil, lubricating oil, and solid paraffin, but in Germany the oils require more chemicals in the refining, and after all the result is not so good. Dr. Scheithauer, Dr. Graefe, and others have described the German methods very fully.

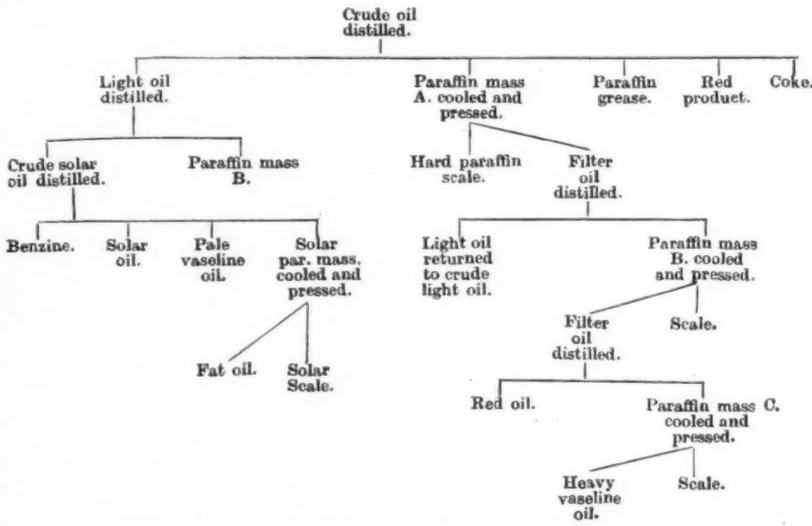
This industry requires a very special brown coal and it is found only in two localities, namely, in the region of Halle on the Saale in Saxon Thuringia, and at Messel near Darmstadt. The material is quite different in the two localities, and the retorting different. The principal center is at Halle, and works are situated between the towns of Weissenfels and Zeitz, and of Aschersleben and Eisleben. The ordinary brown coals of Germany do not contain sufficient bitumen to make retorting profitable. At first it was thought that any brown coal would do, and starting works on this supposition and without proper scientific expert advice, many ended in ruin. So a distinction arises at once between retort-coal and fuel-coal, but it often requires an expert, or chemical examination, to tell the one from the other.

THE SAXON INDUSTRY

The retort coal is found in layers situated among the fuel coal, there often being several layers located at varying depths. There is twice as much fuel coal as retort coal.

Freshly mined retort coal forms a plastic and sometimes greasy mass, of a brownish black color; when dry it is yellow to light brown. The fuel coal becomes black or light brown when dried. Retort coal melts on ignition and burns with a smoky flame; fuel coal does not melt. Retort coal has sp. gr. 0.9 to 1.1; fuel coal 1.2 to 1.4. The value for retorting depends on the proportion of bitument present. The coal is of Tertiary age, Lower Oligocene, and contains 50% to 60% of water. In the Tertiary period the brown coal districts were occupied by extensive bogs with a luxuriant sub-tropical flora. Submerged in swamps the plants and trees were converted into peat as in our own peat-bogs. Sometimes large areas were exposed to atmospheric influences for a time by droughts or alteration of water level, so that the cellulose became partly or completely decomposed and only waxy, fatty, or resinous materials remained, and these covered up later by peat and sediments became through time the retort coal. Botanists state that the plants of that period supplies such wax or resin. The purest bitumen, called pyropissite, was at one time found throughout the coal then used, but seems to be now exhausted. It was yellow in color or in the purest form white. The bulk of the bitumen in the coal is soluble in benzene, toluene, ether, acetone, alcohols, carbon disulphide, and carbon tetrachloride; but the amount and character of the material got in this way depends on the solvent used.

Bitumen is extracted by a solvent, or by distillation with superheated steam under vacuum, and from it montan wax is manufactured. It is a pure white or yellowish wax with a very high melting point, the crude wax having m.pt. 80° or 90° C., refined 70° C. It is manufactured by six companies with a combined output of 400 to 500 tons per annum. The coal is generally dried and then extracted with benzol. There is a wet extraction process in which alcohol and benzine are used at once on the fresh coal, the alcohol removing the water and the benzine dissolving the wax and the solution separating into two layers.



A simplified diagram of a schedule for distillation

The water in the materials as they came from the pit was about 50%. The sulphur is seldom above 1%. The basic substances of the ash are oxide of iron, alumina, and lime, with smaller quantities of magnesia, potash, soda, and sometimes manganese and traces of strontia. These are combined with silica, sulphuric acid, sulphurous acid, hydrogen sulphide, carbon dioxide, traces of hydrochloric acid and occasionally phosphoric acid. The ash is practically of no use as a fertilizer, but it improves the physical state of the soil.

Mining.—The coal is first proved by boring. If the cover is not thicker than the coal it is worked opencast. If, however, the coal is thick, sometimes even up to two of cover to one of coal is worked opencast, and then the cover is removed by steam navvy. With small cover it may be removed by hand. Opencast workings have haulage inclines operated by chain or rope. Most of the retort coal is worked by shafts. The depth is seldom more than 33 fathoms, although a few shafts are over 40 fathoms.

Retorting in Saxony.—At first, as in this country, the retorts used were of the old iron gas-retort type. Various forms were tried. At the last they were made of oval section, 8 to 10 feet long, about 30 inches wide, and 14½ inches deep. Thickness of metal 1 to 1½ inches. A layer of coal 4 inches thick was shoveled in. There were 10 or 12 retorts in a bench, and they were heated by fuel coal of equal volume to the retorted coal. Distillation was completed in 8 hours and the coke raked out. Riebeck, the James Young of Saxony, started building works at Webau in 1858, and built several others afterwards. In 1858 Rolle constructed a vertical retort, and its use became general, and with some minor improvements, is now the only type of retort used in Saxony. It gives a higher yield and a better quality of crude oil, works continuously and with less labor, and puts through five times as much per unit.

The retort is circular, of firebrick and heated by firebrick flues around the outside. Inside the retort a hollow cylinder is made of a series of flat iron rings. The rings are bevelled and arranged above each other louvre fashion, and the coal passes down the narrow space 3 to 4 inches wide between the rings and the brick wall. The products of distillation pass through the louvres into the hollow center of the retort and are carried off to the condensers by a pipe from near the top and another from near the bottom. The top pipe may either pass down outside the bench to join the pipe coming from the bottom, or it may pass downwards inside the retort to join the bottom pipe. A Koerting injector sucks the vapors from the retort through these pipes and passes them on to the condensers. At first all the firing was done by coal. Sometimes gas-firing is now used alone, but generally it is assisted by a fuel coal furnace at the side. Gas-firing, besides being a great economy, has given 20 to 30% increase of distillate. The temperature in the heating flues around the retorts increases from the top downwards from about 400° C. (752° F.) to 600° C. (1,112° F.). The retort was at first 3 feet in diameter and 12 feet high, but is now 5 or 6 feet in diameter and 20 to 25 feet high.

The vapors issuing from the retort should have a temperature of 120° to 150° C. (250° to 300° F.).

In Scotland large amounts of steam are introduced into the shale retorts. No steam is introduced into the Saxon retorts. The raw coal has over 50% of moisture and this supplies the steam. The coal must be crushed or broken by hand, and lumps must not be larger than 1½ to 2½ inches in diameter. If too damp it is partially dried on the charging platforms of the retorts. The moisture content must not be more than 60%, otherwise the coal tends to stick in the retort; nor less than 30% for then the oil vapors are decomposed by the heat, steam being necessary to protect them from decomposition. The top of the retort is closed by a heap of the coal ready to be passed down.

The residue of the distillation is a coke of some value for fuel purposes. It falls into a box below, which is shut off from the retort while the box is being emptied. This box is emptied 30 or 40 times in 20 hours. Automatic arrangements prevent the box being opened before it is shut off from the retort. The coke is dropped into hutches and drenched with water to quench it; or immersed in and hauled through pools of water, as used to be the practice in Scotland.

The retort rings and walls get encrusted in time; after cooling down the retort, the rings are lifted by a tackle and cleaned, and the retort walls are also cleaned. This requires to be done at intervals of 5 to 12 months according to circumstances. The coal ash is basic and the firebricks used must be basic also. If acid bricks are used the ash gets encrusted as a double silicate on the brick, and when cleaning this off, part of the brick breaks off also. The bricks are segments of a circle, keyed into one another, and when building they are ground into each other for tightness. To stand the heat the bricks are best made of pure aluminum silicate. There are various recipes for mortar, of clay, finely ground sand, kaolin, and ground firebrick, mixed with molasses.

* From a paper read before the Edinburgh Section of the Society of Chemical Industry, and published in the Journal of the Society.

The coke after quenching contains moisture 20%, ash 15 to 25%, and the remainder is carbon. It is sold in this state. Its calorific value is 6,000 to 7,000 calories. Up till the middle of the "seventies" the coke was tipped on spoil heaps. Now it is burned in special but very simple stoves for cooking, for heating workshops, in metallurgy as a reducing agent for zinc, and for other purposes.

The retorts are grouped in benches of 10 to 12 in a single row, with a safety wall dividing the benches. The tops are protected by walls with felt roofing. Retorts are estimated to last a dozen years. The through-put of retort coal seems to be about 3 tons per retort per 24 hours, and less than this if the coal is rich.

The condensing is all done by air-cooling. The vapors are passed through thin-walled malleable iron pipes beginning 36 inches diameter and decreasing further on to 31, 28, 20, 16 and 12 inches, finally finishing up in 1 inch pipes. They are all horizontal until near the end when they are vertical. For a retort 5 or 6 feet in diameter a condensing surface of 900 to over 1,000 square feet is allowed. Slow cooling is held to be necessary. Water cooling has been tried and rejected, although lately tried again. The suction from retort to condensers used to be by Koerting steam injectors; but now fans are much more in favor. There is no oil-scrubbing of the gas for spirit in Saxony, as there is at Messel and in Scotland.

In Saxony the water condensed along with the crude oil amounts to 40 to 50% of the retort coal, and more if Koerting injectors are used for propelling the vapors. The amount of ammonia in the water is only 0.03 to 0.07% and it does not pay to recover it, although efforts have been made to do so. The liquor is supplied to neighboring farmers gratis. It does not pay to convey to any distance. The great bulk of it has to be sent into the streams after some purification by aeration and filtration, or by filtering through spoil heaps. It contains besides ammonia, aldehydes, ketones, methyl alcohol and acetonitrile, with acetic, propionic, butyric and valeric acids and catechol, and is faintly alkaline in reaction.

The crude oil contains hydrocarbons of various aliphatic series, and also acid and basic substances, with some aromatic compounds. The cellulose, humic acids and bitumens of the coal produce their own products of decomposition. There is about 0.3% of nitrogen in the coal, and in the crude oil there is ¼ to ½% of nitrogenous bodies; 10% of the nitrogen of the coal is found in the crude oil, 12% in the condensed water, 66% in the coke, and 12% in the gas. These vary with the kind of coal and the method of distillation. The Rolle type of retort is adhered to on account of the good coke it produces.

In the Saxon field there are 12 works putting through together about one million tons of brown coal per annum, producing 60,000 tons of crude oil and yielding over 7,000 tons of solid paraffin. The crude oil yield now is about 18 gallons to the ton of coal. (Scottish production of crude oil is 273,500 tons per annum.)

THE MESSEL INDUSTRY

Retorting methods.—The industry began in 1885. The retort coal is quite different from that of Saxony, and is distilled differently. It seems unique in its nature, being a mixture of bituminous clay and coal, and having the organic matter in combination with the mineral matter. The bitumen cannot be extracted by solvents. It has a high percentage of moisture, like brown coal, and a high percentage of ash, like shale. It is more lumpy than the Saxon brown coal, which allows steam to pass through it in the retort. It lies under not more than 13 feet of cover, and is about 480 feet thick. It fills an ancient hemispherical depression, and is in layers like an onion. There are 240 acres of surface. It is worked down 80 feet or so and will last a long time. The fossils indicate a joint animal and vegetable origin. It has the consistency and cut of Dutch cheese, is blackish green in color, with conchoidal fracture when dry. Alternate frost and thaw make it separate into thin sheets like paper. The moisture is 45%, the ash 30%. The calorific value is low and would not pay cost of carriage for heating purposes. Dry distillation in the laboratory yields water 44%, crude oil 7.8%, coke-residue 36%, gas 6.2%. The condensed water contains volatile and fixed ammonium salts together with catechol and its homologues. The ammonia is recovered. In the fixed ammonium salts are quite a series of homologous fatty acids. The ash is rich in iron oxide.

The crude oil is distilled from the coal in the presence of steam, and the coke is dropped into a gas-producer below and the gas used to heat the retorts. There is no marketable coke. At one time a special stove was used to reduce the moisture from 44% to 6%, the dried material was distilled in the presence of steam, and the coke dropped into the gas-producer. Thus coal was consumed in drying the retort coal, and also in raising steam from water for the coal distillation. Now the moisture of the coal is used as a steam for the retort. Vertical retorts are used of a type somewhat similar to that used in Scotland (see Ger. Pat. 200,602, May 23, 1906). The working is continuous. There is a hopper on top from which the coal is let into the retort by a valve as required. More than two-thirds of the retort is of iron; the lower part is of firebrick, and this is the gas-producer, and from it the coal ash is dropped into a hutch below. In the top part of the retort the coal is dried and the steam resulting is drawn from the top by an electrically driven fan; a part is returned into the retort further down, and part caught by another fan is passed into the bottom of the gas-producer where superheated steam acts on the carbon and nitrogen to produce water-gas and ammonia. The oil is distilled at the middle of the retort and the products of distillation led off from here to the condensers. The flues around the retorts are much more spacious than the flues of the Scotch retorts. The flues are divided by partitions into three compartments, and from one compartment to the one above there is communication by a comparatively small passage. The result is that there is a surging circulation of the products of combustion in each compartment, keeping each at the required temperature, and only a quantity passes off towards the chimney in proportion to the suction. The utilization of heat is good. The products of combustion pass to the chimney at 200° C. The vapors passing from the retort get partially cooled which causes the separation of ammoniacal liquor containing fixed ammonium salts, and some soluble organic compounds. The still hot vapors are passed on up a kind of Glover tower where all the ammonia is absorbed by dilute sulphuric acid. The ammonium sulphate solution so obtained is concentrated by the heat of the vapors, and after being centrifuged and dried the product is ready for the market. The oil vapors pass from the Glover tower and are cooled by water condensers. The water now condensed along with the oil is free from ammonia, and to reduce the quantity of effluent it is used in tubular condensers and towers and so is much evaporated. The gas is finally led up heavy-oil towers to catch the light spirit still left in it. From 70 to 80% of the permanent gas (some 10,000 cubic feet per ton) is used for heating the retorts; the rest goes to the power station. It may be used to raise steam, or after purification from hydrogen sulphide with iron oxide, it may go to gas engines. There is above 20% of carbon dioxide in the gas, and when this is absorbed the gas is well adapted for incandescence lighting. The ammoniacal liquor is passed down a tower-still with alkali, and the ammonia absorbed in sulphuric acid. From the spent water catechol and its homologues are recovered, and also fatty acids. The Germans extract every practicable substance from their by-products.

At one time the retort coal at Messel was graded, and yielded 4 to 14% of crude oil; now all goes together and averages about 7½% (=19 gallons per ton).

Would a retort of this type not be suitable for distilling a rich peat? Air-dried peat might serve quite well if moist peat is too wet. Peats no doubt vary in the proportion of bitumen they contain and they ought to be examined from this point of view. The brown coals of our Colonies should also be investigated.

Refining in Saxony. Distillation.—The crude oil is of a yellow-brown or dark brown color, sp.gr. 0.850—0.890, usually determined at 44° C. When richer coal was obtainable the sp.gr. was sometimes as low as 0.820 to 0.850 and seldom above 0.880. The present-day crude oil is generally 0.880 to 0.900. It sets between 20° and 30° C. The constituents boil at 80°—400° C., the greatest volume between 250° and 350° C.

The refining of the crude oil is in outline the same as in Scotland. The operations consist of several distillations with fractionation, treatments with sulphuric acid and with caustic soda between the distillations, and separation of the solid paraffin from the heavier oils by cooling and pressing. The first distillation is always partly a destructive distillation, and gives a deposit of carbon and production of permanent gas.

The distillations in Scotland are done at atmospheric pressure, and in the presence of steam more or less superheated. In Saxony they are carried on sometimes at ordinary pressure, sometimes under extra pressure, sometimes under partial vacuum; sometimes with steam, often without; but under pressure it is not for "cracking." The stills are vertical cylinders with hemispherical bottoms for a charge of 440 to 550 gallons, not more; this is only one-fourth of the size of the smallest of our Scotch stills. The height of the still is 5 feet and the width at top 5½ feet; the cover is domed and is made in one piece with an exit-pipe about 20 inches long. There is a manhole in the center of the top, 20 in. × 24 in. The stills are bricked in in various ways so as to protect them from direct impact of the flame and send the products of combustion around the flues. The material is cast-iron, rarely wrought iron. Cast steel has been tried and rejected. Till comparatively recent years it was the invariable custom to work each still independently. The condensers are circular coils of piping in a vertical cylindrical water-tank. The coil is about 27 yards long, made of lead or iron, that is of gas-piping, or of cast iron semi-circular segments with flanges. The cooling surface per still is 85 to 95 sq. ft. Between the condenser and receiver there is a "U" bend and from between the condensers and this there rises a pipe to lead the permanent gas upwards into the atmosphere or onward to a gas-holder. There are two receivers, one at each side, each of 33 gallons capacity. When partial vacuum is used it is produced by Koerting steam injector or a vacuum pump.

[TO BE CONTINUED]

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, OCTOBER 20, 1917

Published weekly by Munn & Company, incorporated Charles Allen Munn, President; Frederick Converse Beach, Secretary; Orson D. Munn, Treasurer, all at 233 Broadway, New York

Entered at Post Office of New York, N. Y., as Second Class Matter

Copyright 1917 by Munn & Co., Inc.

The Scientific American Publications

Scientific American Supplement (established 1876) per year $5.00
Scientific American (established 1845) 4.00
The combined subscription rates and rates to foreign countries, including Canada, will be furnished upon application.
Remit by postal or express money order, bank draft or check.

Munn & Co., Inc., 233 Broadway, New York

The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

Back Numbers of the Scientific American Supplement

SUPPLEMENTS bearing a date earlier than January 1st, 1916, can be supplied by the H. W. Wilson Company, 39 Mamaroneck Avenue, White Plains, N. Y. Please order such back numbers from the Wilson Company. Supplements for January 1st, 1916, and subsequent issues can be supplied at 10 cents each by Munn & Co., Inc., 233 Broadway, New York.

WE wish to call attention to the fact that we are in a position to render competent services in every branch of patent or trade-mark work. Our staff is composed of mechanical, electrical and chemical experts, thoroughly trained to prepare and prosecute all patent applications, irrespective of the complex nature of the subject matter involved, or of the specialized, technical, or scientific knowledge required therefor.

We also have associates throughout the world, who assist in the prosecution of patent and trade-mark applications filed in all countries foreign to the United States.

Branch Office:
625 F Street, N. W.,
Washington, D. C.

MUNN & Co.,
Patent Solicitors,
233 Broadway,
New York, N. Y.

Table of Contents

PAGE

Homeomerism 262
The Effects of X-Rays Upon Diseases of Bacterial Origin.—By Christopher Kempster 262
A Ghost of the Past.—4 illustrations 264
Ferro-Concrete Ships.—4 illustrations 264
Some Latter-Day Problems of the Foundry.—By Dr. Richard Moldenke 264
German Engineering from Within 264
Formation of Aniline from Ammonia and Benzene at High Temperatures 264
The Wrens.—By A. A. Allen.—9 illustrations 265
Building a Complete Cycle of Industries.—By Victor V. Kelsey 265
The Production of Tin 265
Soundness of Grain 265
Sulphur Mixture for Grapevines 265
Molybdenum and Ferro-Molybdenum 265
The Making of a Six-Inch Reflecting Telescope.—III.—By C. J. Larson.—6 illustrations 265
The Etiology of Some Obscure War Diseases 265
Washing Dishes 265
Shelling the Enemies in the Air 265
Soap Substitutes and Washing Powders 265
The Brown Coal Distillation Industry of Germany.—I.—By D. R. Steuart 265